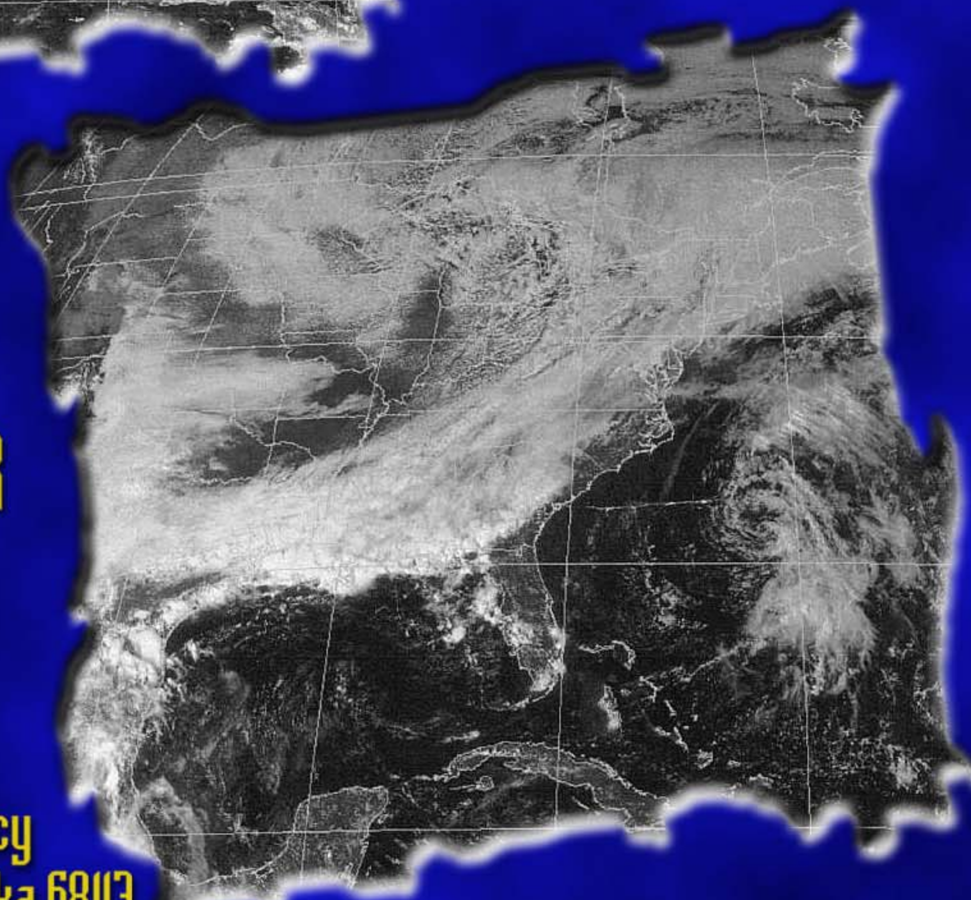
AFWA/TN-04/001

13 February 2004

AUTUMN REGIMES



BY

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REVIEW AND APPROVAL PAGE

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13. Abstract: This technical note presents a back-to-basics approach to forecasting the weather in this transition from the weaker, slower moving weather systems of summer to the stronger, more dynamic weather systems of winter. It is especially designed for new and inexperienced forecasters, but it is also an excellent review for all forecasters. As summer ends, the subtropical ridge begins to retreat drift southeastward. The polar jet begins to shift farther southward, and polar air intrusions become more frequent as autumn progresses. By the end of the autumn transition period into winter, drastic changes in weather conditions become more common. This technical note presents synoptic patterns and regimes that routinely occur during the autumn months. Synoptic pattern recognition remains one of the most important considerations when producing a forecast and will help in determining if forecast model guidance is "on track."

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PREFACE

This Technical Note is the fourth of the four Forecaster Memos (FMs) being revised and updated with later satellite images and model guidance. These seasonal weather patterns FMs were originally published by Third Weather Wing (3 WW) in the early 1980s.

The information presented within this Technical Note is a cumulation of weather information that I have gained over 27 years as an Air Force weather forecaster, and after retirement from active, 16 years as a Civil Service Lead Forecaster in the Severe Weather Section of the AFGWC and AFWA's Production Floor.

Considerable knowledge was gained over the 16 years in the Severe Weather Section while observing weather conditions across the continental United States in preparation of the Military Weather Warning Advisories (MWAs) and also the issuance of Point Weather Warnings (PWWs). Certain weather patterns (regimes) for each season routinely occurred. A seasoned forecaster can spot evolving weather events across the country using their analysis package, satellite and model guidance.

The information that will be presented pertains to analyses, satellite interpretation and empirical rules. Some empirical information was extracted from my 3 WW publications: *Gulf Moisture Advection*, *Major Midwest Snowstorms*, *Satellite Interpretation*, and *Freezing Precipitation*. Some of the information dates back to the 1970s. However, "weather is weather," and events that occurred 30 years ago will keep repeating into the future. New methods and equipment to help forecasters has changed dramatically through the years. There has been an explosion of auxiliary weather information within the past few years through the Internet. So much weather data is available through the National Weather Service and many universities.

Very little model-forecast data will be presented. The intent behind the absence of model guidance is to show that forecasters can produce short-term forecasts on their own by analyzing charts and interpreting satellite data. As mentioned above, there is so much model data available, that one can become confused as to what product is best. Forecasters who become comfortable in analyses and satellite interpretation will have little trouble in initializing the zero hour model packages. The empirical rules that will be presented have been developed from many case studies throughout the years. These rules are intended as tools for synoptic pattern recognition of the potential for autumn storm regimes and their associated weather.

This Technical Note was written in a common sense "back to basics" approach and has been especially designed for new and/or inexperienced forecasters. Also, it should be an excellent review for all forecasters for the upcoming autumn season. The Technical Note is basically composed of synoptic patterns and regimes that routinely occur during the autumn months. Although, autumn officially begins in mid-September and continues through mid-December by the calendar date, I have included most weather information and case examples for autumn regimes from mid-September through mid-November. By mid-November, the onset of winter conditions occurs more often. Synoptic pattern recognition is still one of the most important considerations when producing a forecast and will help in determining if model guidance is "on track." Hopefully, I believe this Technical Note will help future forecasters for years to come regardless of any new numerical model improvements and/or new systems that will come on line.

ACKNOWLEDGMENTS

Special acknowledgments go to Air Force Weather Agency's Commander and senior Staff for the funding that allowed me to continue part-time writing and publishing Technical Notes. This part-time position, which ended 30 September 2002, was managed through Science Applications International Corporation (SAIC).

Thanks to Technical Sergeant Gina Vorce, AFCCC/DOPA, and Patty Mumford, AFWA/DNTT for their graphics support.

Special thanks to Mike Jimenez and Gene Newman, former and present Air Force Combat Climatology Center Climate Analysis Team (AFCCC/DOPA) Technical Editors, for their review, layout and design, editing and additional writing, and formatting in getting this Technical Note ready to publish.

Very special thanks to Master Sergeant Mike Brooks, AFWA/DNTT, for his assistance in overseeing the final publication of this TN.

Finally, I acknowledge my wife, Doris, for continued understanding of my interest in my profession even after retirement.

EUGENE M. WEBER

Chapter 1

INTRODUCTION

In Air Force Weather (AFW), a regime is defined as "a specific synoptic and/or mesoscale weather pattern that affects the local weather at a particular location." Weather regimes occur at all scales of motion; however, the dominant local effects are usually associated with the synoptic scale weather pattern (highs, lows, fronts, etc.). In some cases, significant local effects are associated with mesoscale patterns (low-level jets, cold air damming, land/sea breezes, etc.).

The following synoptic regimes and patterns are intended to remind forecasters of changes that occur during the summer to winter transitional period over the continental United States. The subtropical ridge, which is prevalent across the United States during summer, slowly retreats southward during October. Cutoff low systems appear by early autumn usually south of 40º N. By mid-October, trough systems become more pronounced and penetrate deeper into the United States as shown in the cover figure. In the top cover figure, a mid-September visible photo shows the beginning of the transition from summer to autumn. A stationary frontal system stretches across the northern United States while tropical depressions appear over the southeastern United States and Mexico. In the lower photo, approximately two weeks later, the transition is to an autumn/winter regime. A cold front extends to the Gulf of Mexico and upslope stratus lies over the western Great Plains.

Forecasting the weather in November can be difficult due to rapidity of major upper air changes from the slow-moving systems of summer. By October, forecasters should have "brushed up" on their winter forecasting techniques and rules. Winter-type events may occur by late October, i.e., significant snow events over the western United States and the western high plains of the central United States. Major storm development over the central and eastern United States is likely by mid-November. Some November weather patterns are presented in AFWA/TN-01/002, Winter Regimes, which would be a good review for late autumn.

Chapter 2

SYNOPTIC REGIMES

UPPER LEVELS

General Circulation. The summer's subtropical ridge/high pressure regime may continue through late summer and into early autumn as shown over the central and southern United States in Figures 2-1 and 2-2. By mid October, however, a continuing southerly shift and strengthening of the

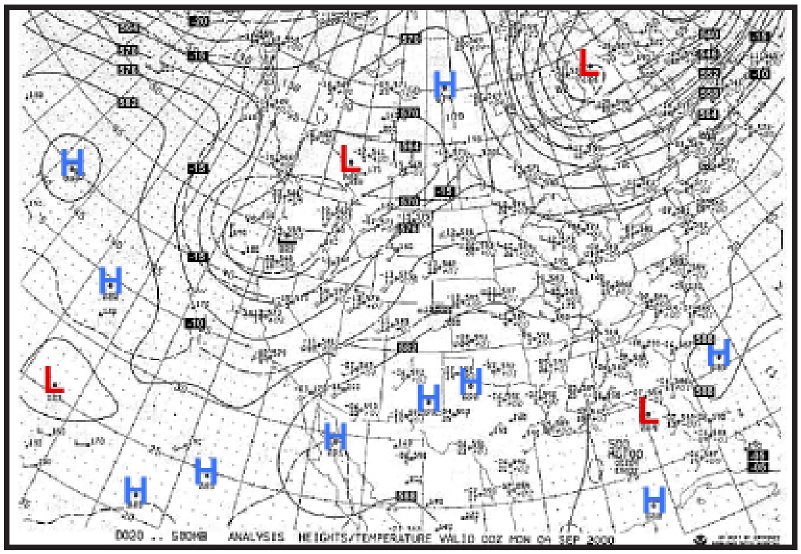

Figure 2-1. 500-mb Analysis, 0000Z/4 September 2000. Subtropical high in place over the southern Great Plains.

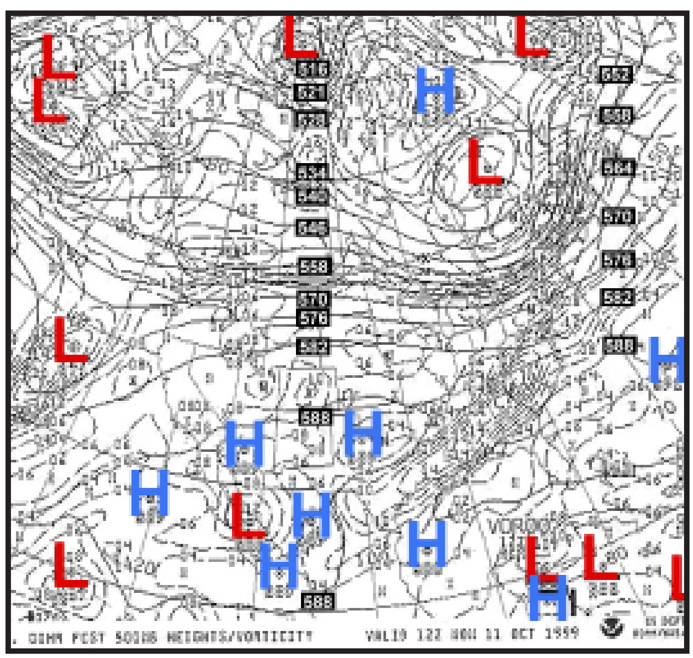

Figure 2-2. 00-Hour 500-mb Heights/Vorticity, 1200Z/11 October 1999. The figure depicts zonal flow with a Polar jet shown over southern Canada. and a subtropical ridge extending across the central and southern United States.

westerlies south of Alaska and across Canada into the northern United States eventually forces the subtropical ridge southward across the Gulf of Mexico and Mexico as shown in Figure 2-3.

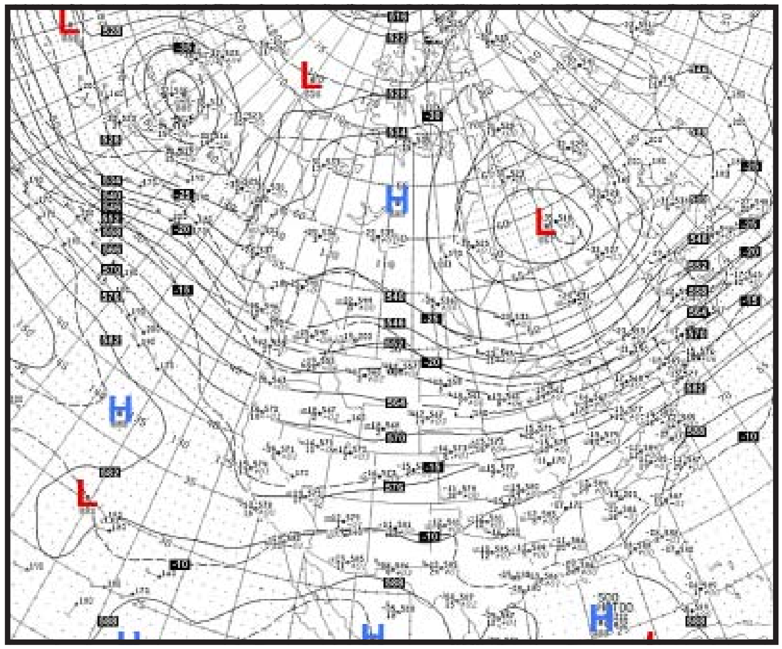

Figure 2-3. 500-mb Analysis, 0000Z/22 October 2001. The subtropical ridge continues southward to its eventual winter location. Westerly flow strengthens across the United States.

ZONAL REGIMES.

Short Wave Troughs. During late September and continuing through autumn, short wave troughs become more frequent and stronger and extend southward into the lower two-thirds of the United States as shown in Figures 2-4 through 2-6.

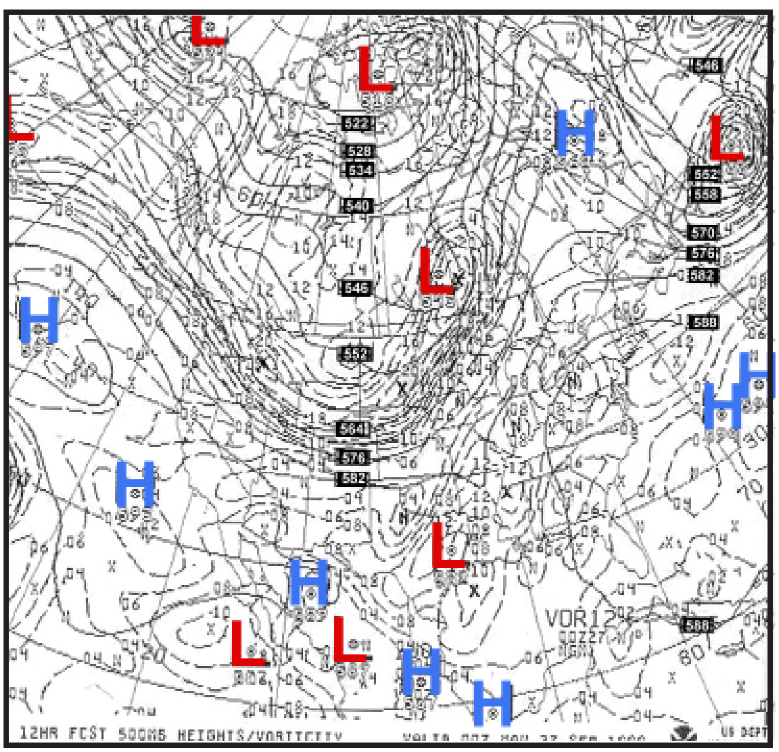

Figure 2-4. 12-Hour 500-mb Heights/Vorticity, 0000Z/27 September 1999.

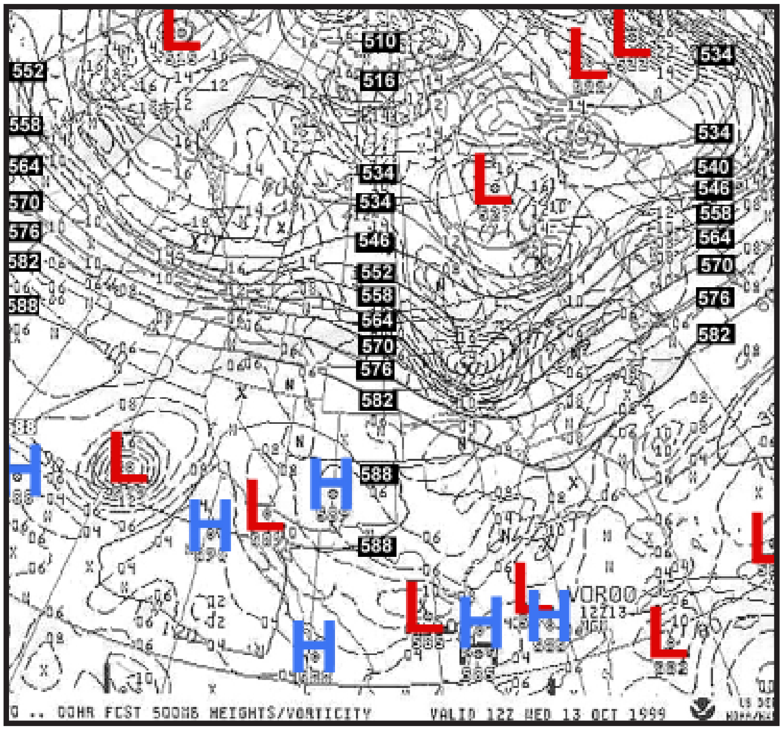

Figure 2-5. 500-mb Heights/Vorticity, 1200Z/13 October 1999. The presence of the subtropical ridge/high may continue in October as shown over the southwestern United States.

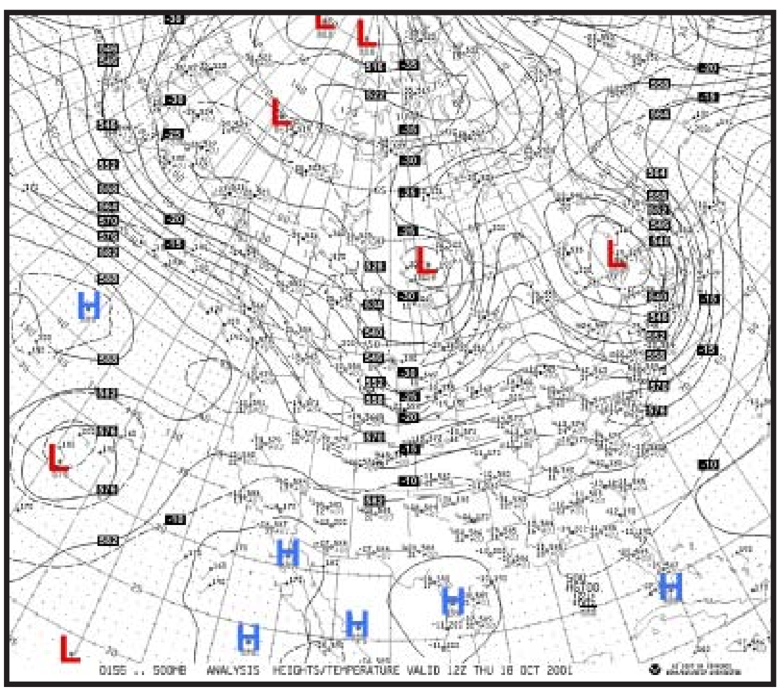

Figure 2-6. 500-mb Analysis, 1200Z/18 October 2001. Short waves are tracking across the United States. The associated upper lows continue to track over Canada through October.

Strong amplitude short wave troughs, which may take on the appearance of a long wave trough (long wave troughs usually don't appear until November), may begin in October as depicted in Figures 2-7 and 2-8. The major trough regime shown in Figures 2-7 and 2-8 may persist for several days. In this particular event, considerable cloudiness and precipitation occur over the eastern two-thirds of the United States as shown in Figure 2-9. Strong short waves with closed lows over the United States appear during November as shown in Figure 2-10.

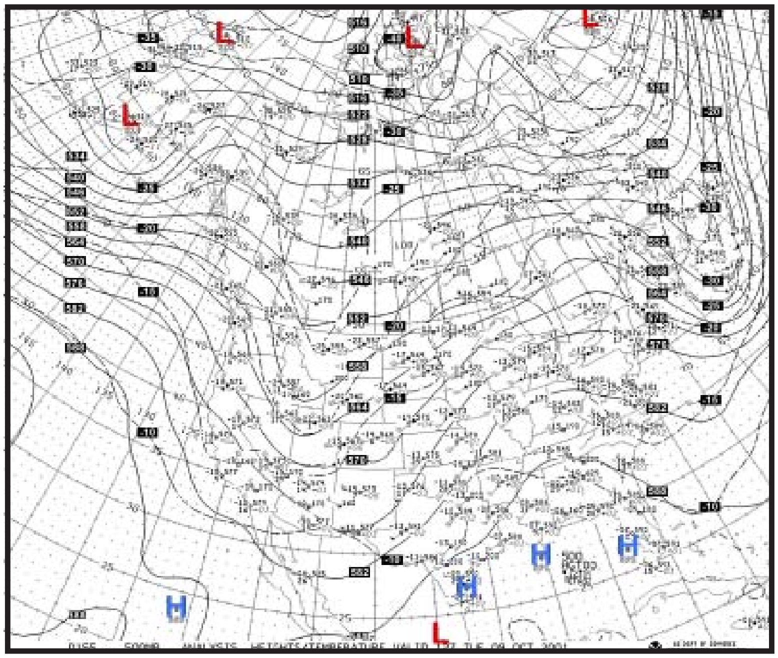

Figure 2-7. 500-mb Analysis, 1200Z/9 October 2001.

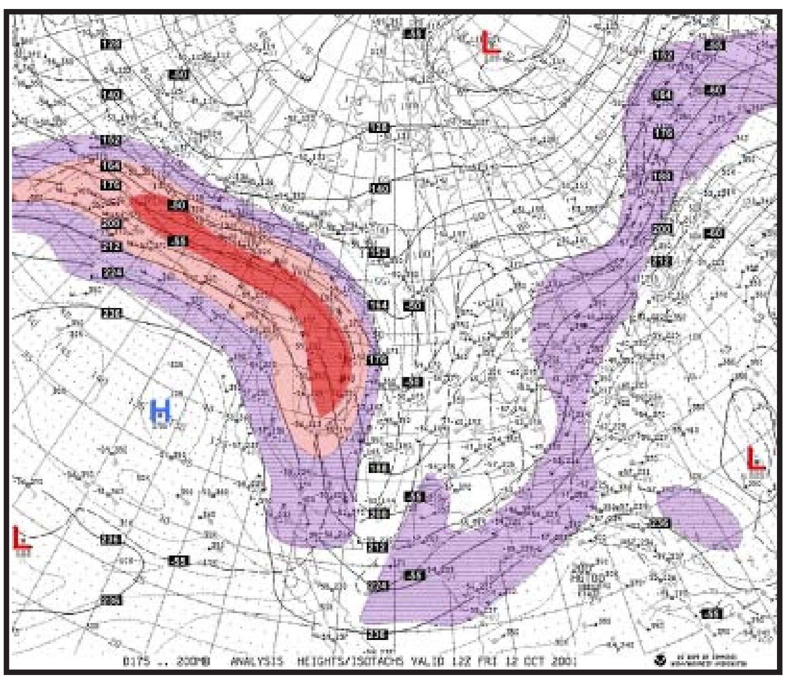

Figure 2-8. 200-mb Analysis, 1200Z/12 October 2001. Three days later than Figure 2-7. The short wave trough shown appears to be a long wave trough. The short wave continued eastward for the next several days.

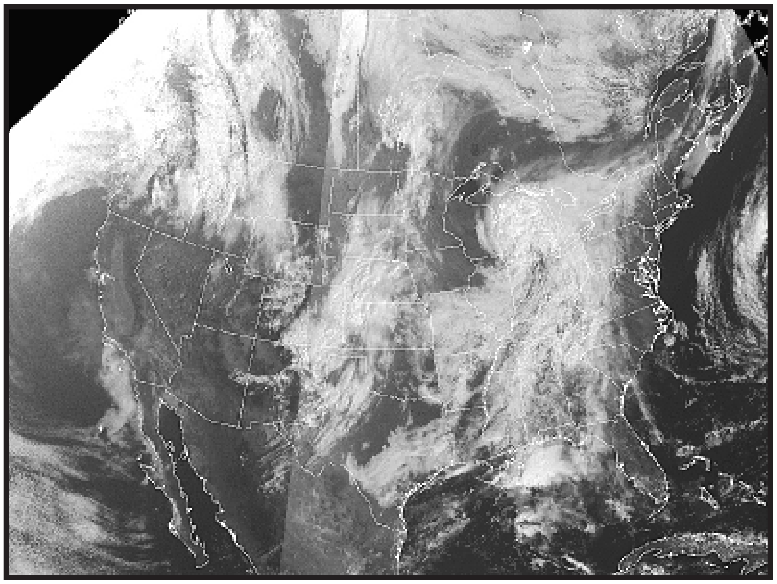

Figure 2-9. GOES Composite, 1530Z/12 October 2001. Three and one-half hours later than Figure 2-8.

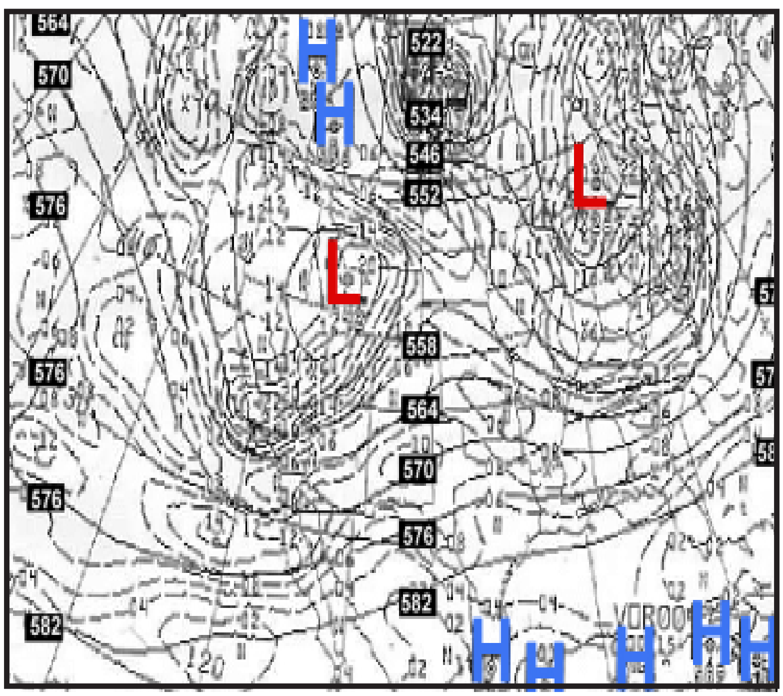

Figure 2-10. 00-Hour 500-mb Heights/Vorticity, 0000Z/15 November 2000. Short wave troughs intensify and closed lows may appear within these troughs.

Long Wave Troughs. At the onset of autumn and continuing through October, long wave troughs generally are not noticeable over the central and southern United States due to the presence of the subtropical ridge. During November, however, the strengthening westerlies continue southward, which results in tighter contour and thermal gradients and large-scale troughs and ridge systems (Figures 2-11 and 2-12). Major trough systems over the United States begin to appear due to an increasing temperature differential between warmer ocean (ridges) and colder land (troughs) areas. Significant storm systems appear across the United States by mid-autumn when short waves interact within long wave troughs as depicted in Figure 2-11. Closed lows that develop within long wave trough systems generally appear in early November (Figure 2-11). These are associated with the large-scale circulations. A winter-type meridional trough/ridge regime is shown in Figure 2-12 (an early November event). This regime is more common during January and February.

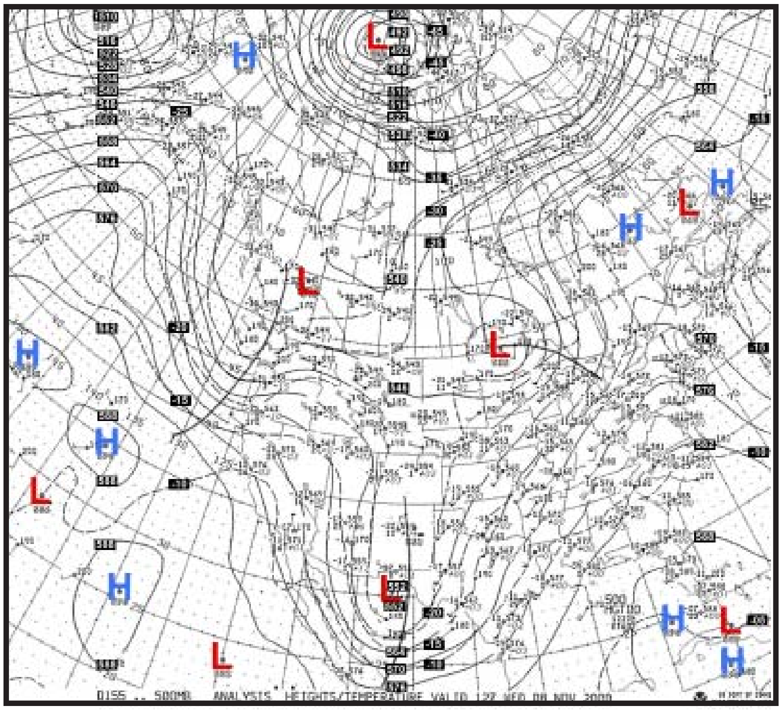

Figure 2-11. 500-mb Analysis, 1200Z/8 November 2000. A long wave trough lies across the central United States. Three distinct short waves are shown. Short wave recurvature within the base of the long wave occurs over the Central Plains.

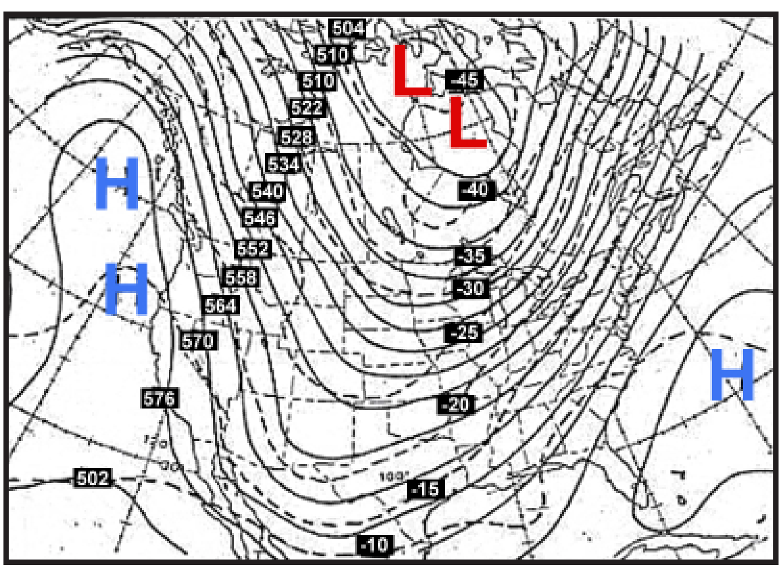

Figure 2-12. 500-mb Analysis, 1200Z/10 November 1979. Meridional trough/ridge regime.

As winter approaches, tighter contour, vorticity and thermal gradients, associated with stronger short waves, become more frequent as illustrated in the long wave regime in Figure 2-13.

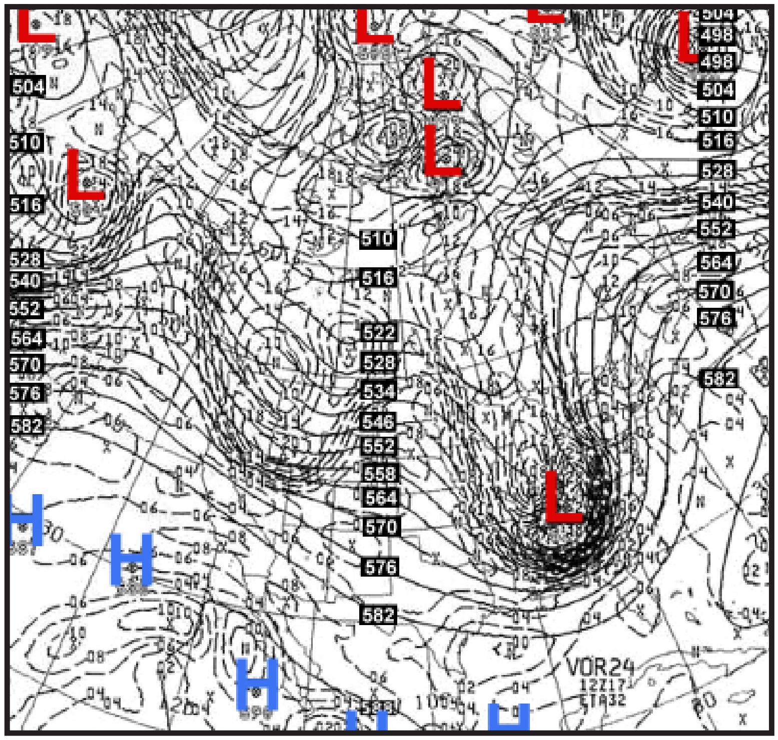

Figure 2-13. 24-Hour 500-mb Heights/Vorticity, 1200Z/17 December 2000. A long wave trough located over the eastern United States as indicated by the northwest to southeast flow across the United States. Short waves are moving southeastward into the long wave.

So far, discussions relating to closed-low formation within deepening troughs have been presented. The following information pertains to cutoff low regimes - an annual autumn event. Don't become confused between closed lows and cutoff lows. Cutoff lows are not associated with the primary westerly (and polar jet) flow as closed lows are. Cutoff lows, as an entity, have a weaker jet stream associated with them.

Cutoff Lows. Cutoff lows appear more often during the transitional periods of autumn (and to a lesser degree in spring) because the belt of westerlies still lies across the northern United States and Canada. In Figure 2-14, cutoff lows are shown over Florida and the southwestern United States. Occasionally, short wave trough systems moving through the westerlies extend far enough southward into the central and southern United States so that conditions favorable for a closed low circulation are established (Figure 2-15). Prior to and during the cutoff period, the main jet stream continues to lie to the north although a weaker jet may appear within the cutoff low circulation. Cutoff lows may occur over any area of the United States at any time of the year. They seem to favor the area over the southwestern United States and adjacent ocean areas (Figure 2-16). These systems often move slowly, and it is not uncommon for one to appear continuously on the upper air charts for a week or more. Cutoff lows sometimes appear as a result of blocking patterns and may remain nearly stationary for days until the block has broken down (see Figures 2-14 and 2-15).

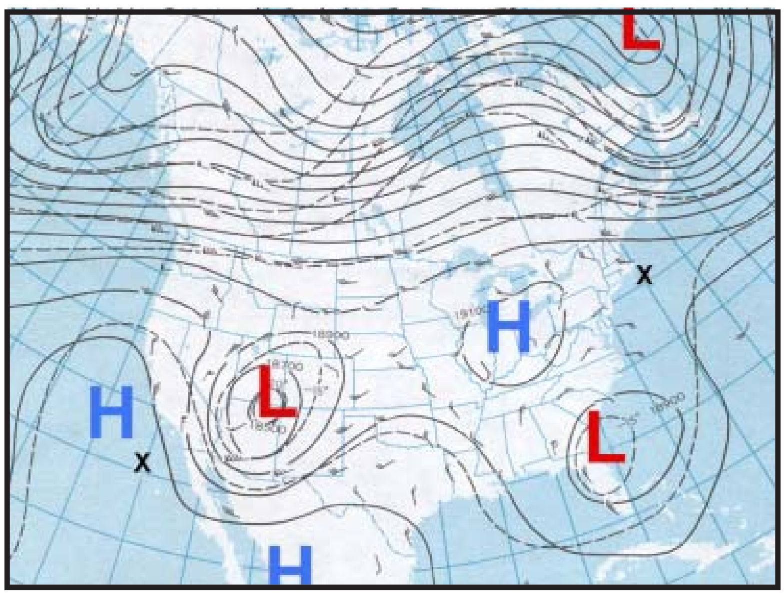

Figure 2-14. 500-mb Analysis, 1200Z/3 November 1978. Primary westerly flow is shown over Canada. Cutoff lows and a blocking high appear over most of the United States.

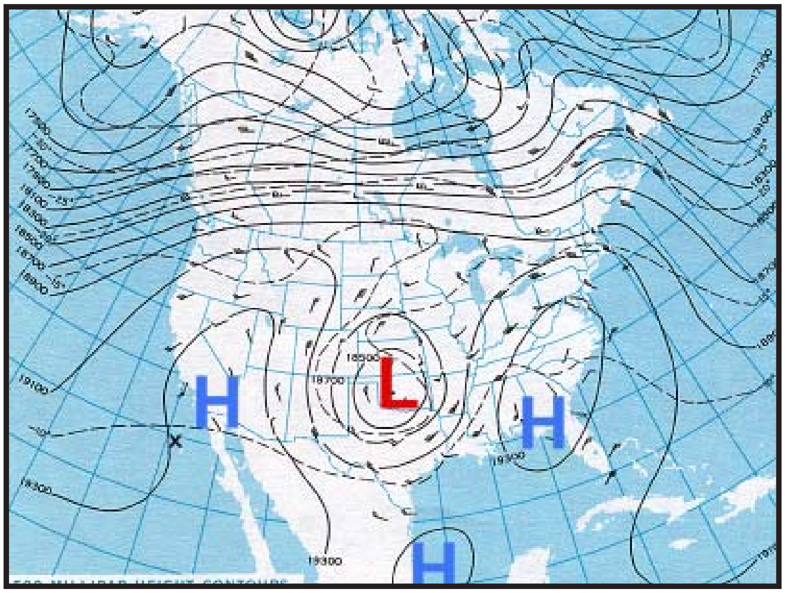

Figure 2-15. 500-mb Analysis, 1200Z/1 November 1981. Blocking high and cutoff low regime is shown. The high cells shown over the eastern and western United States are not subtropical. High-pressure system shown over eastern Mexico is subtropical.

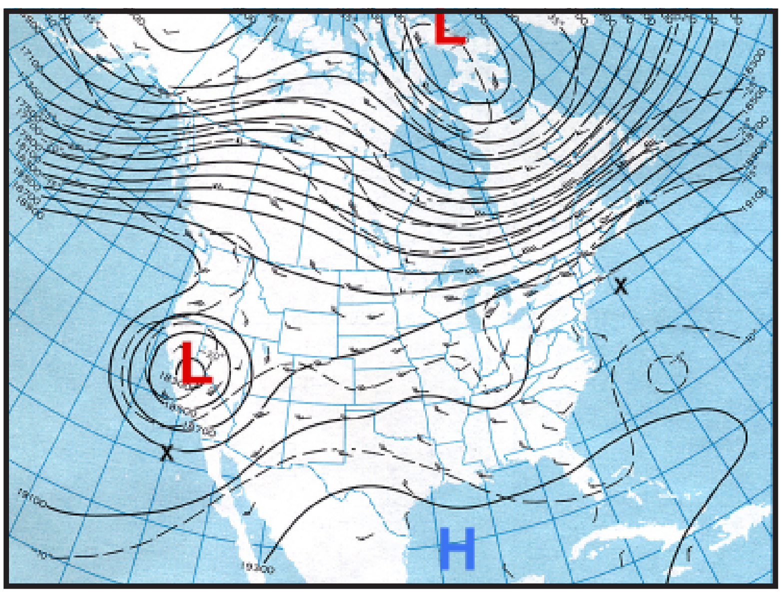

Figure 2-16. 500-mb Analysis, 1200Z/31 October 1978. Excellent example of a cutoff low system. Prevailing westerlies and associated jet streams lie across Canada.

In Figure 2-17, a cutoff low appears over the southern Great Plains—high cells are shown on either side of the low. Mature cutoff lows often become barotropic as shown and begin to dissipate. The vorticity isopleths are in phase with the contour flow indicating a barotropic pattern. Locations affected by these stagnant systems may experience the same weather conditions for several days in a row. Forecasting the overall movement of a cutoff low is a challenge.

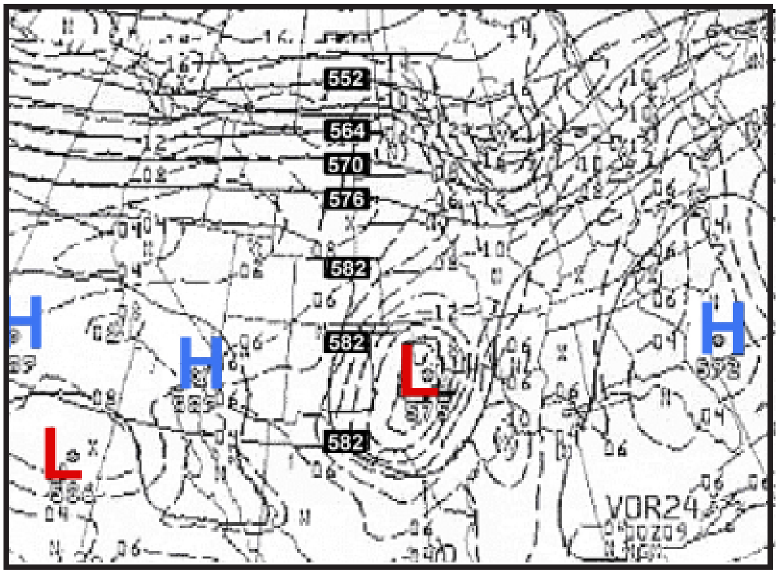

Figure 2-17. 24-Hour 500-mb Heights/Vorticity, 0000Z/ 9 October 1999. Cutoff low is shown over Texas. Vorticity isopleths nearly in phase with the contours.

The surface weather associated with these systems varies and is dependent upon the cutoff low's area of development. Generally surface gradients are weak and a low may not appear on the surface in association with the upper low (see Figures 2-18). Heavy rains and flooding conditions may occur over the central and eastern United States for several days when a cutoff low moves into or develops over the south central United States. Due to the slow track of these systems, Gulf moisture generally advects into these systems over a long period of time.

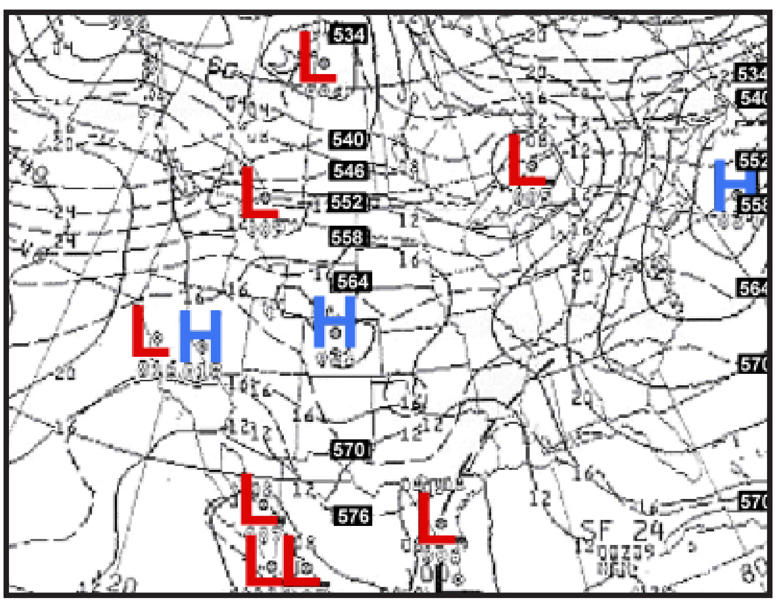

Figure 2-18. 24-Hour Mean Sea-Level Pressure/1000- to 500-mb Analysis Thickness, 0000Z/9 October 1999. This Figure is related to Figure 2-17. The inverted trough depicted over eastern Texas and the lower Mississippi Valley is the surface feature of the cutoff low. Note the cutoff low's thickness cold pocket over northern Texas.

Another cut off low example that occurred in November 2001 is shown in Figure 2-19 through Figure 2-21. This system remained nearly stationary over Texas for several days and produced heavy rains over eastern Texas.

In Figure 2-19, the 500mb center is noted just east of El Paso, Texas. The water vapor satellite photo shown in the insert depicts a pronounced cyclonic circulation. The heavier rainfall occurred within the brighter area over eastern Texas. Figure 2-20 depicts the surface conditions valid at the same time as Figure 2-19. Notice there is no surface low associated with the upper low—only a surface trough. The 24-hour precipitation totals ending at 1200Z are shown in Figure 2-21

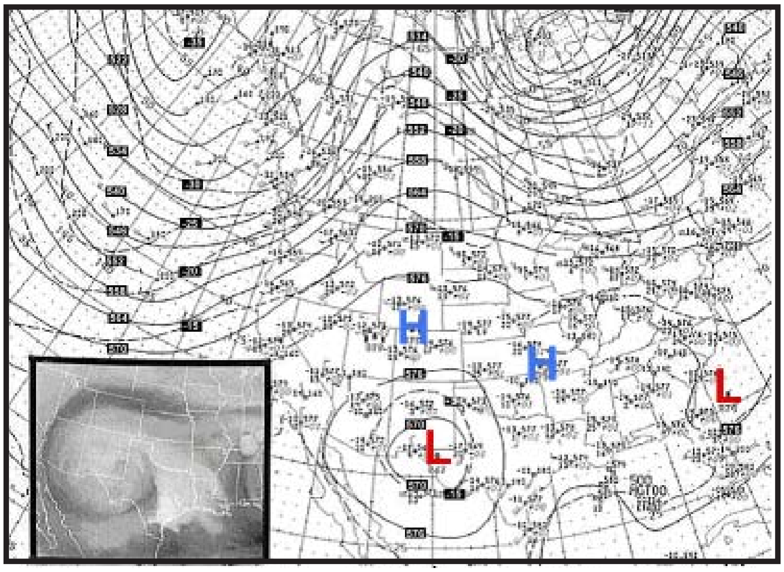

Figure 2-19. 500-mb Analysis, 0000Z/16 November 2001. Inset: Water vapor imagery from the same time.

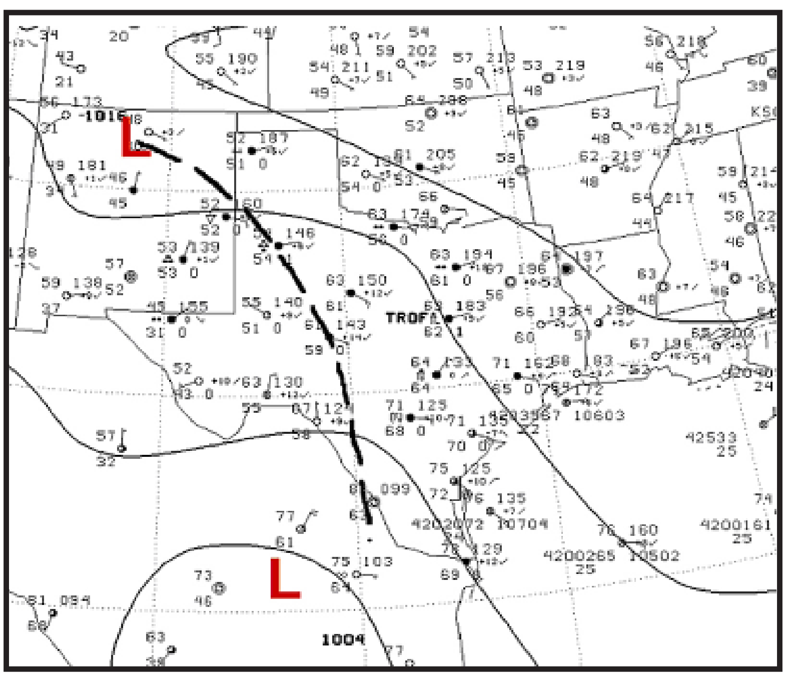

Figure 2-20. Surface Analysis, 0000Z/16 November

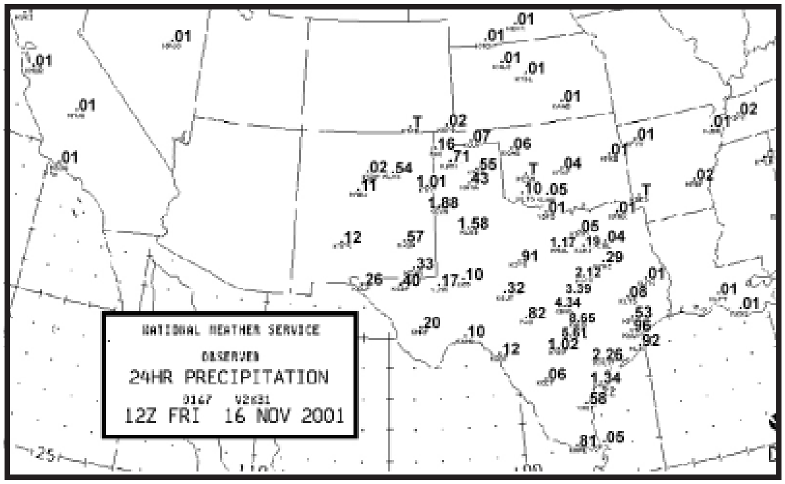

Figure 2-21. 24-Hour Precipitation, 1200Z/16 November 2001.

JET STREAM REGIMES

Polar Jet. The polar jet stream, which is located north of 45° N during the summer months, generally begins its migratory movement southward by late September and early October as shown in Figures 2-22 through 2-24. The subtropical ridge and its associated jet stream drifts southward and by mid October is no longer a feature on upper air charts. In Figure 2-22, an early autumn event, the polar jet has shifted southward. Several jet stream branches are shown; the southern branch of the polar jet is noted over the Pacific Northwest. By November, the polar jet continues southward across the southern United States (Figure 2-23).

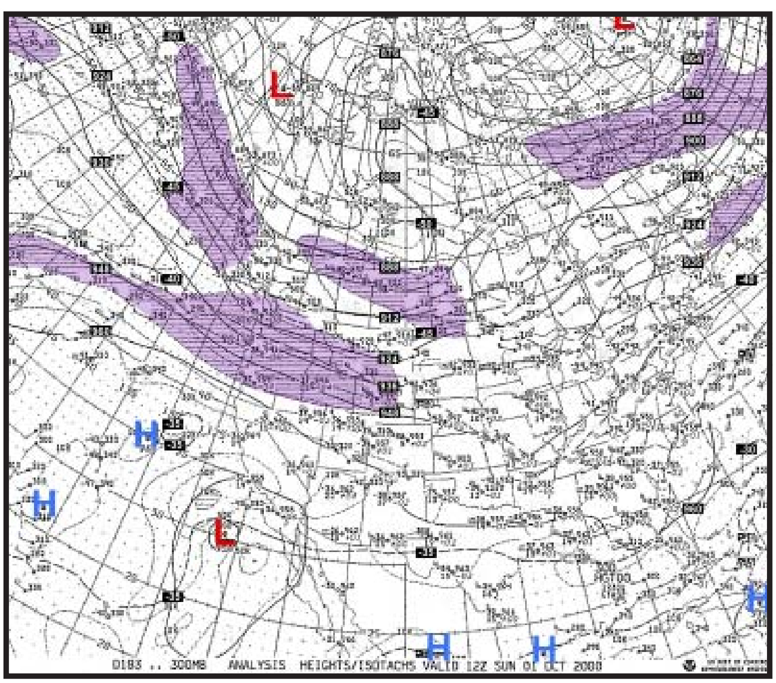

Figure 2-22. 300-mb Analysis, 1200Z/1 October 2000. Polar jet streams have shifted southward. The southern branch is noted over the Pacific Northwest. Subtropical ridge has weakened over the southern United States.

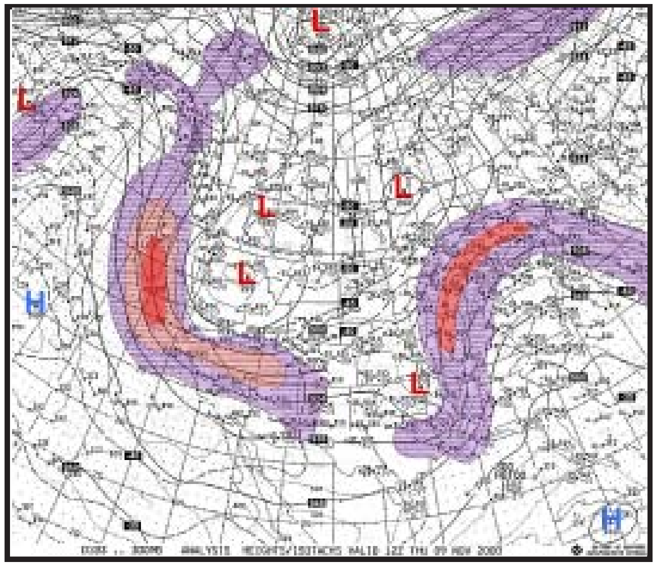

Figure 2-23. 300-mb Analysis, 1200Z/9 November 2000. Polar jet streams appear across the United States

In the final illustration, Figure 2-24, the polar jet has continued to strengthen as it shifts southward and covers a large area of the United States.

Note: AFWA/TN-01/002, *Winter Regimes*, contains more detailed discussions on jet stream analysis based on satellite interpretation.

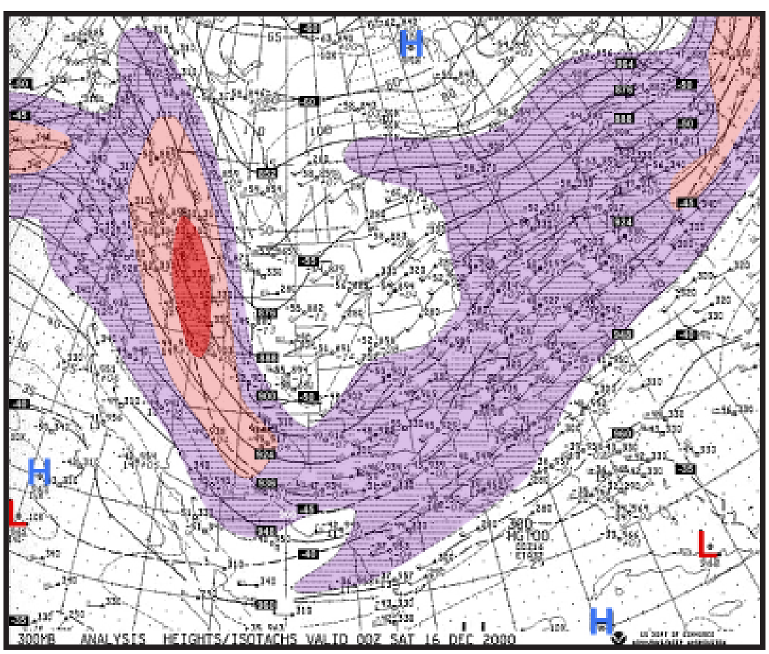

Figure 2-24. 300-mb Analysis, 0000Z/16 December 2000. As the winter season approaches, jet stream systems continued to strengthen.

Subtropical Jet The subtropical ridge and its associated jet stream system gradually shift southward by late autumn as the polar jet becomes the prevailing jet stream system. During autumn, the subtropical jet is a important “player” in the advection of heat and moisture northward when low-latitude short waves systems move across the southwestern United States and into the southern Great Plains as shown in Figures 2-25 and 2-26.

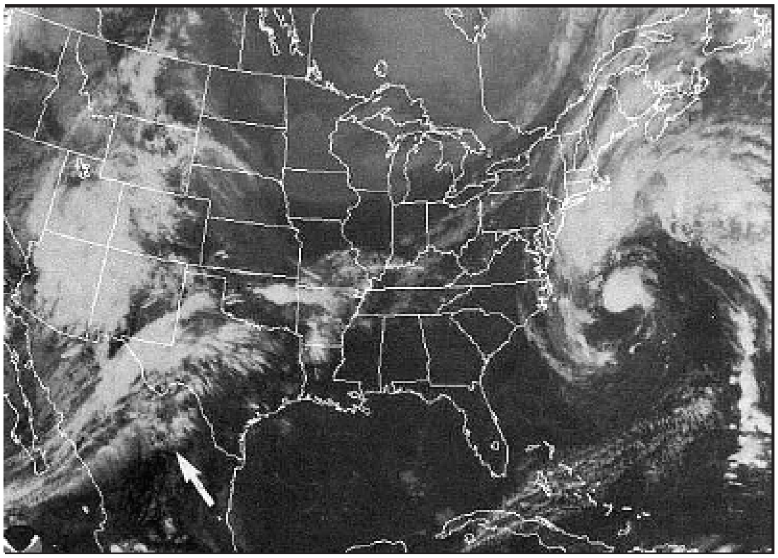

Figure 2-25. GOES East Visible, 2145Z/27 October 2000. Subtropical jet, noted by the arrow, is moving northeastward ahead of an Arizona storm system.

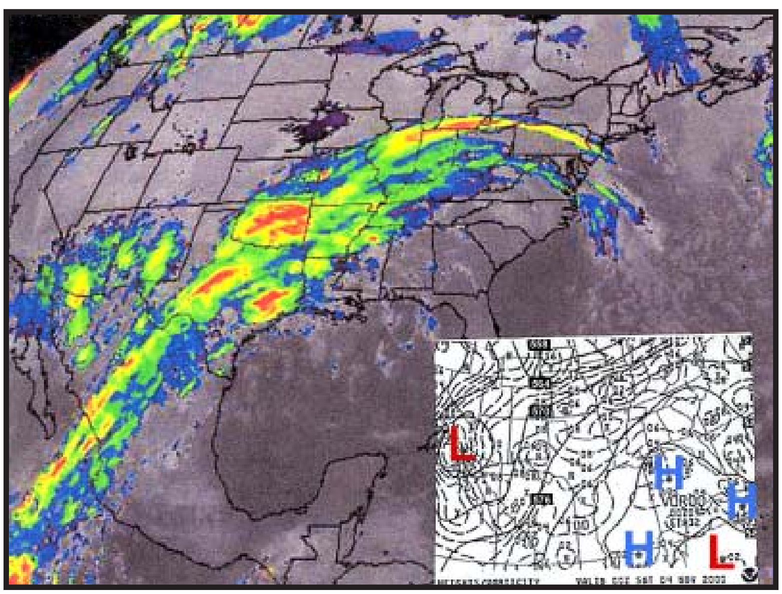

Figure 2-26. GOES East Enhanced Infrared, 0415Z/4 November 2000. (Inset: 12-Hour 500-mb Heights/Vorticity, 0000Z/4 November 2000). Strong subtropical jet has lifted northeastward across the central United States ahead of a southwestern United States storm system. Color enhanced photo reveals high-level cirriform clouds over the Southern Plains states.

LOWER LEVELS/SURFACE

Anticyclonic Regimes.

Maritime Polar Air Masses. As a result of a predominately fast zonal flow during early and mid-autumn (Figure 2-27), many Pacific maritime polar (mP) air masses march across the United States as shown in Figure 2-28. These fast-moving Pacific frontal systems generally bring favorable weather conditions across the nation because gulf moisture generally does not have sufficient time to advect

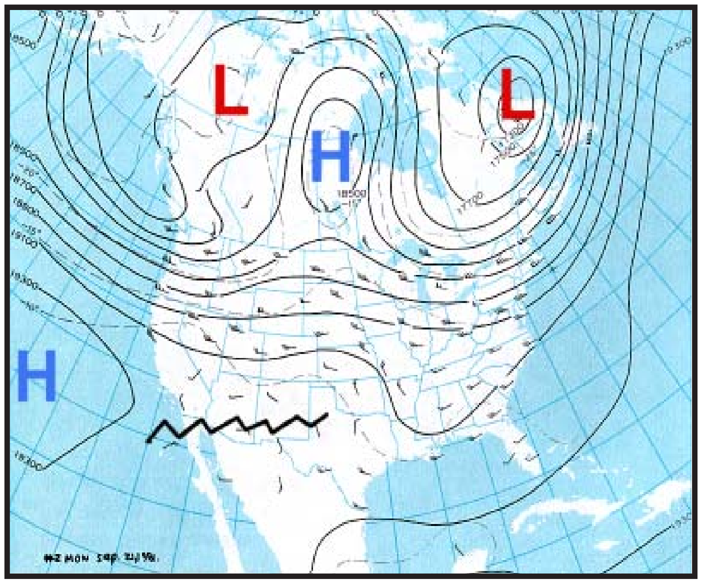

Figure 2-27. 500-mb Analysis, 1200Z/21 September 1981. Fast west to east zonal flow regime. Subtropical ridge noted across the southern United States

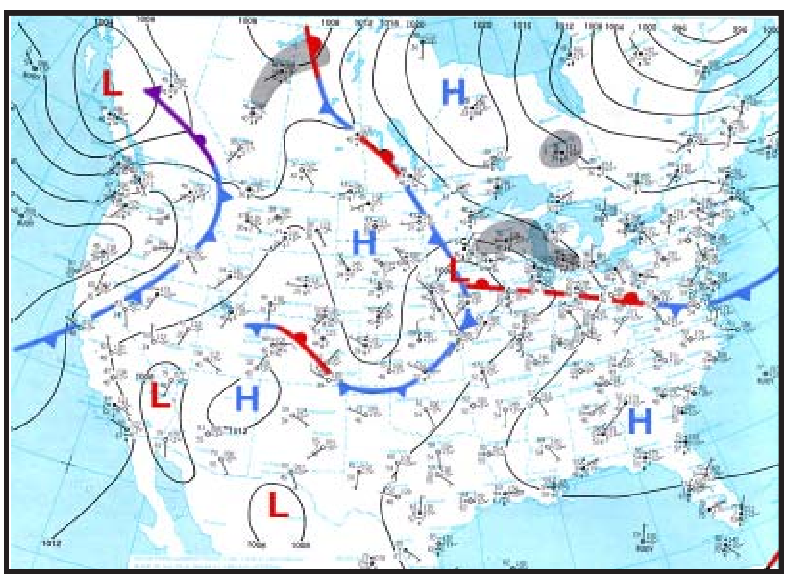

Figure 2-28. Surface Analysis, 1200Z/21 September 1981. (Related to Figure 2-24) Pacific maritime polar fronts associated with short waves.

ahead of the fronts to produce precipitation. Figures 2-29 and 2-30 depict two more early autumn examples of mP frontal activity across the northern and central United States.

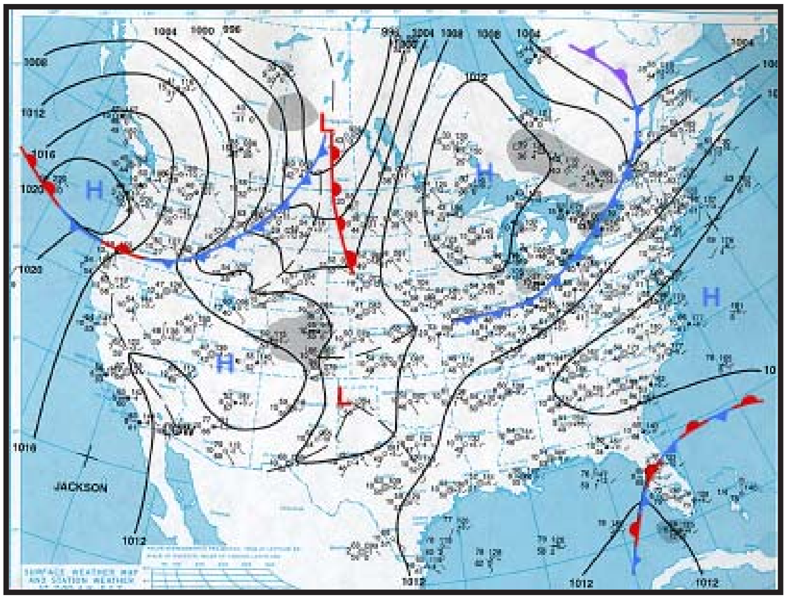

Figure 2-29. Surface Analysis, 0300Z/25 September 1999. Another example of Pacific maritime cold fronts moving across the United States.

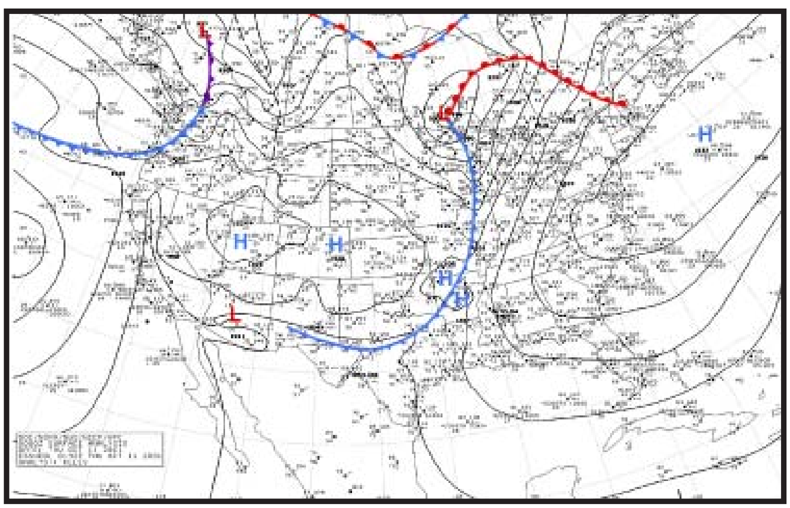

Figure 2-30. Surface Analysis, 0000Z/11 October 2001.

Continental Polar Air Masses. By October, Canadian cP air masses become more frequent over the United States as shown in Figure 2-31. Figure 2-31 illustrates a typical early fall scenario during the transition from summer to winter. A cP air mass has moved southward into the central and eastern United States. Three days later (Figure 2-32), the cP air mass has pushed deep into the southern United States and the Gulf of Mexico.

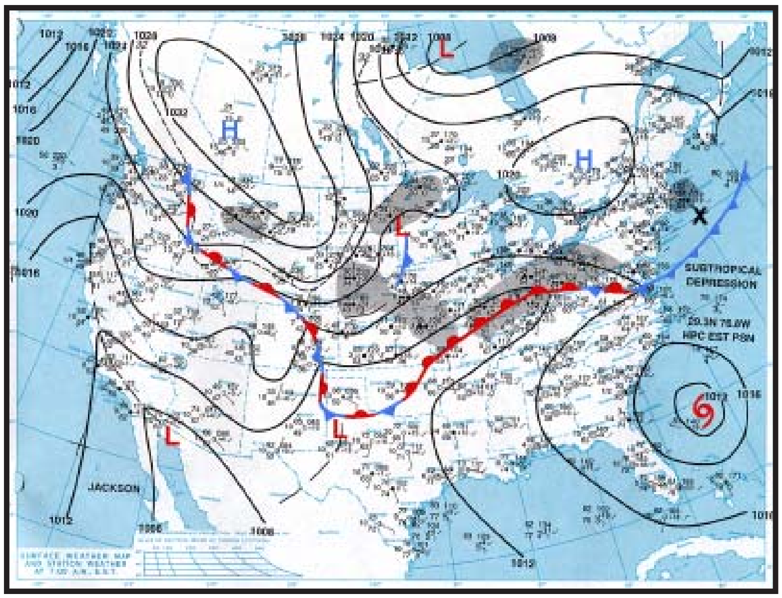

Figure 2-31. Surface, 1500Z/5 October 2000.

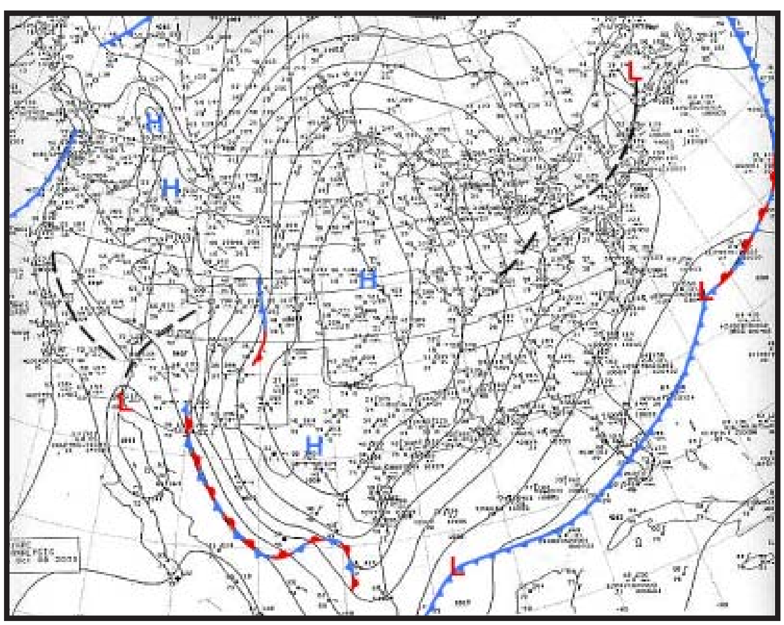

Figure 2-32. Surface, 1800Z/8 October 2000. Strong cP air mass for the autumn season prevails over a large area of the United States.

Receding High Regime. Figure 2-33 depicts the normal surface pressure pattern sequence across the United States prior to potential storm formation over the Midwest. Migratory cP highs from Canada or mP highs from the western United States are moving towards the eastern United States resulting in surface trough development and eventual low formation along the lee slopes of the Rockies. Stationary or building cP highs over northern Canada often extends a cold polar ridge into the upper Midwest as shown in Figure 2-33 Southerly low-level jets (often nocturnal) develop east of the lee-side trough, which induces gulf stratus from Texas/Gulf of Mexico to move rapidly northward along the jet prior to the emergence of the approaching storm system. The polar jet generally lies across the central United States. Often, there is little precipitation occurring east of the Rockies at the beginning of these events. Precipitation develops rapidly with the introduction of gulf moisture and an increase in PVA associated with the approaching disturbance. This regime generally begins in October and continues through winter. Major snowstorm development across the central and upper Midwest may occur by late November. Figure 2-34 depicts another example. A major storm developed over the central Great Plains with severe thunderstorms and strong gradient winds.

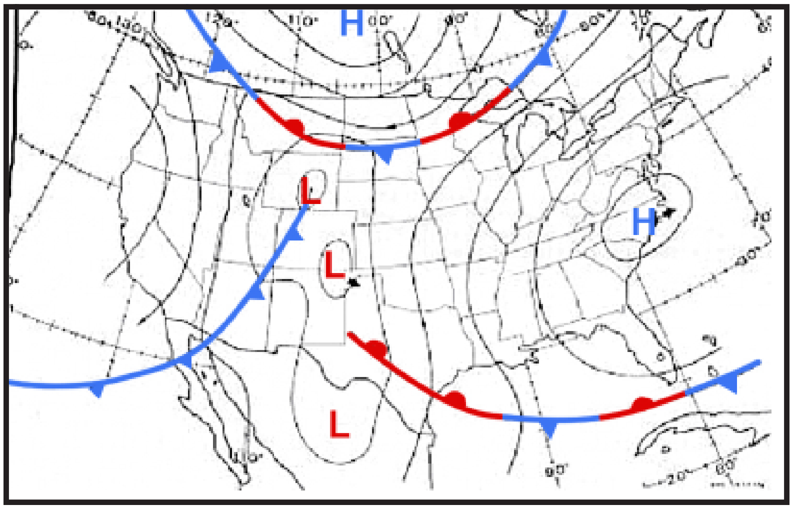

Figure 2-33. Model, Receding High

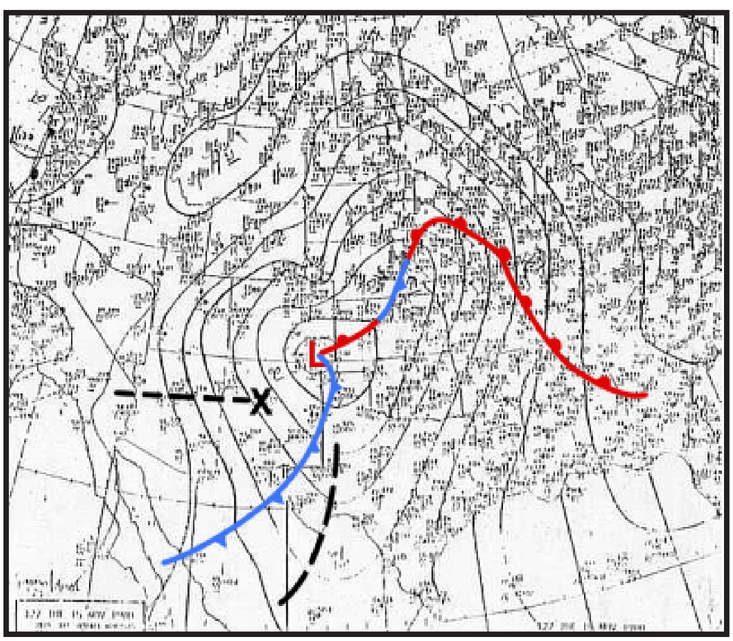

Figure 2-34. Surface, 1200Z/15 November 1988. The "X" denotes the related height falls center.

Prevailing High Regime. In Figure 2-35, a persistent zone of high pressure extends from the Pacific Northwest across the Rocky Mountains and eastward to the eastern United States. Lee-side trough/low development is not favorable under such an anticyclonic, cold airmass; consequently, the surface cyclonic pressure pattern associated with the approaching pacific mP system would be represented by an inverted trough configuration. The polar jet generally lies across the southern states. Likewise, low-pressure system tracks lie across the southern United States as depicted in Figure 2-35. Residual stratus and widespread overrunning precipitation is often associated with this regime. Prevailing high regimes generally begin in November. Figure 2-36 illustrates a late October prevailing high regime.

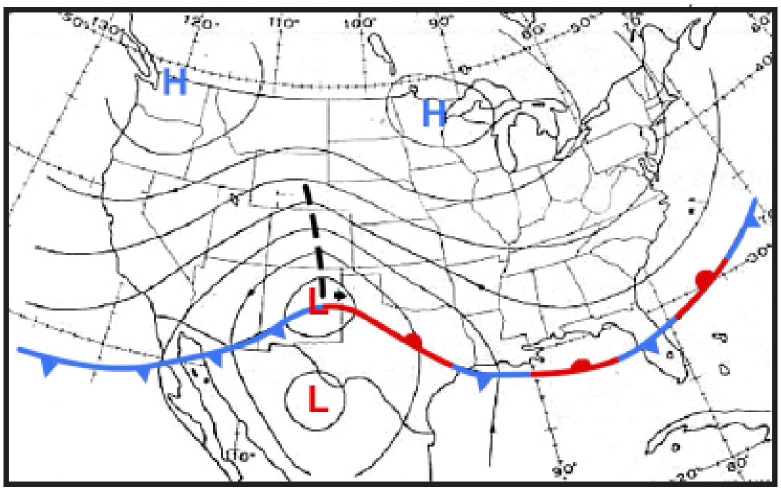

Figure 2-35. Model, Prevailing High.

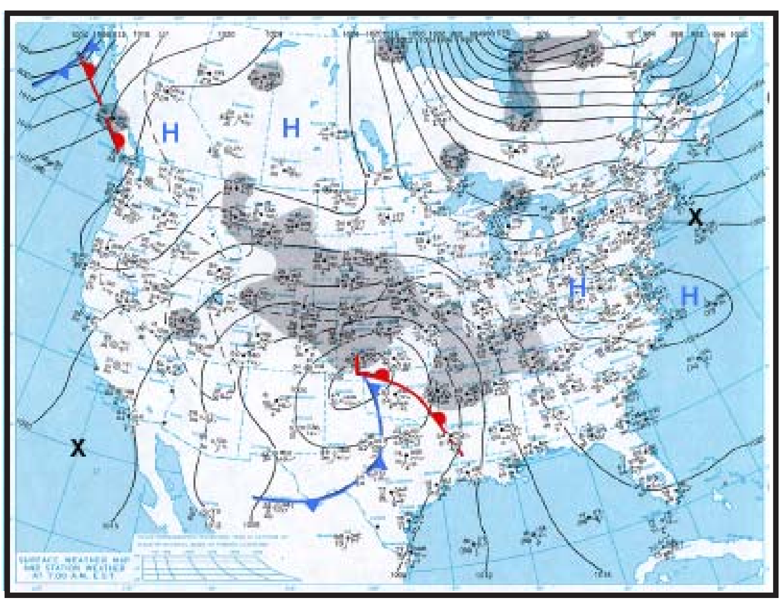

Figure 2-36. Surface, 1200Z/27 October 1980. High pressure prevails across the northern and central United States. Extensive precipitation is seen within the polar ridge as the Colorado low moves eastward.

Chapter 3

WESTERN UNITED STATES

UPPER LEVELS. More detailed information on short wave and long wave movements over the western United States is presented in Winter Regimes. The following upper level discussions are general and serve as a reminder for the transition into winter season.

Short Wave Troughs. By mid-October, many Pacific short wave troughs move onshore and track across the western United States as shown in Figure 3-1. Some of these troughs may undergo cyclogenesis and closed lows appear as shown in Figures 3-1. The information presented here discusses Pacific upper trough cyclogenesis when these systems move inland and are affected by mountain ranges.

Split Flow. Split flow cyclogenesis is the most prevalent form of significant cyclogenesis over the

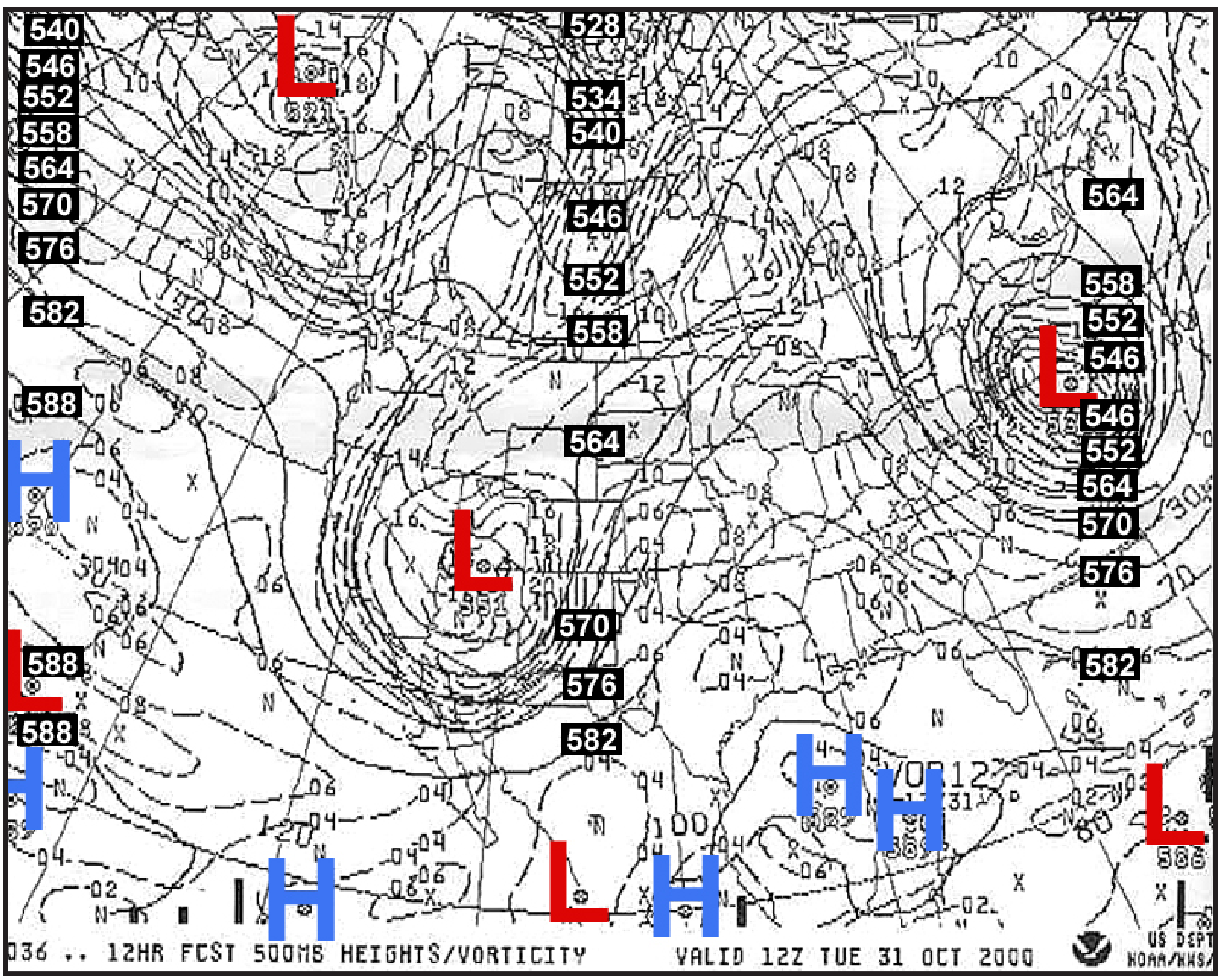

Figure 3-1. 12-Hour 500-mb Heights/Vorticity, 1200Z/31 October 2000.

western United States during the cold season (Figures 3-2 and 3-3). The split flow regime is most often induced by a major mountain chain. Split flow patterns occur frequently in areas such as on the west side of the common blocking patterns; however, a jet stream in the southern branch of the flow must exist to induce cyclogenesis (Figure 3-4). Thus, split flow cyclogenesis is less common than split flow. Split flow cyclogenesis develops within the mid levels; The models deal with vorticity at the 500-mb level and no

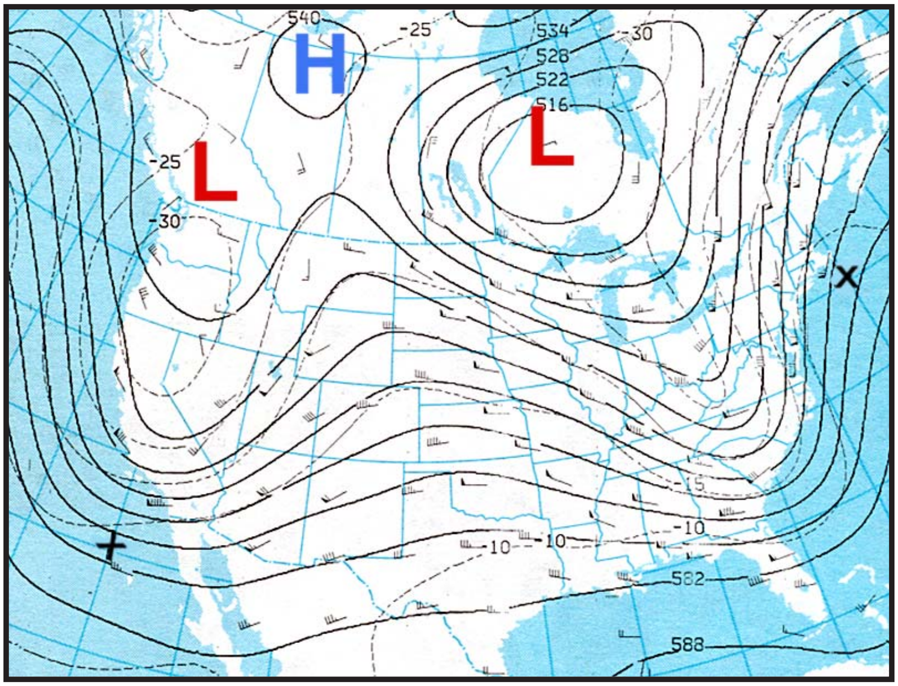

Figure 3-2. 500-mb Analysis, 0000Z/25 November 1983. Two pronounced short wave systems. A cold pocket that appears west of Oregon is often the first clue of 500-mb cyclogenesis.

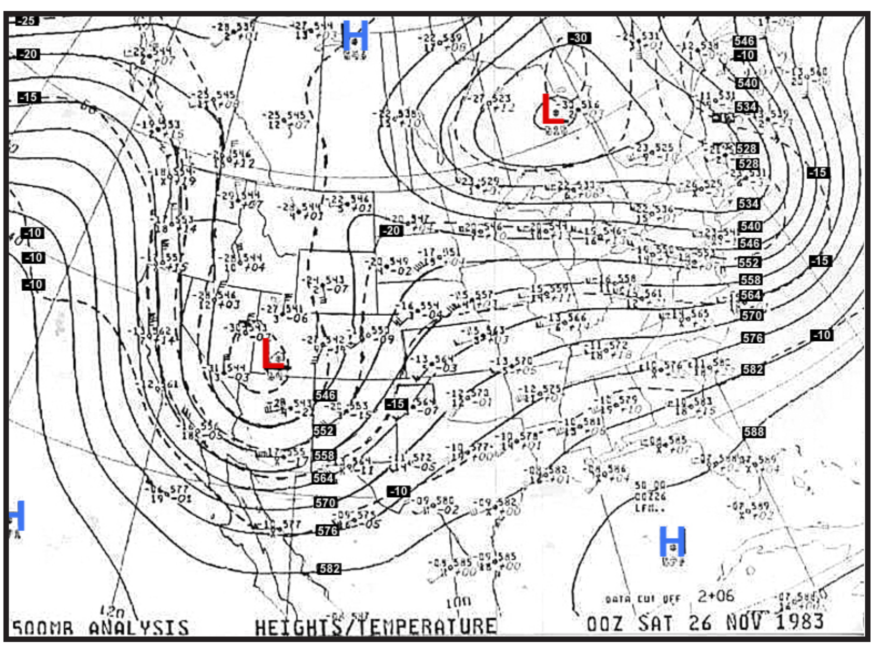

Figure 3-3. 500-mb Analysis, 0000Z/26 November 1983. Twenty-four hours later from Figure 3-2. A low has developed as shown over southern Utah.

place else. Hence, any development of low pressure systems would be first apparent at the 500-mb level.

Another example of a split flow regime is shown over the western United States in Figure 3-5.

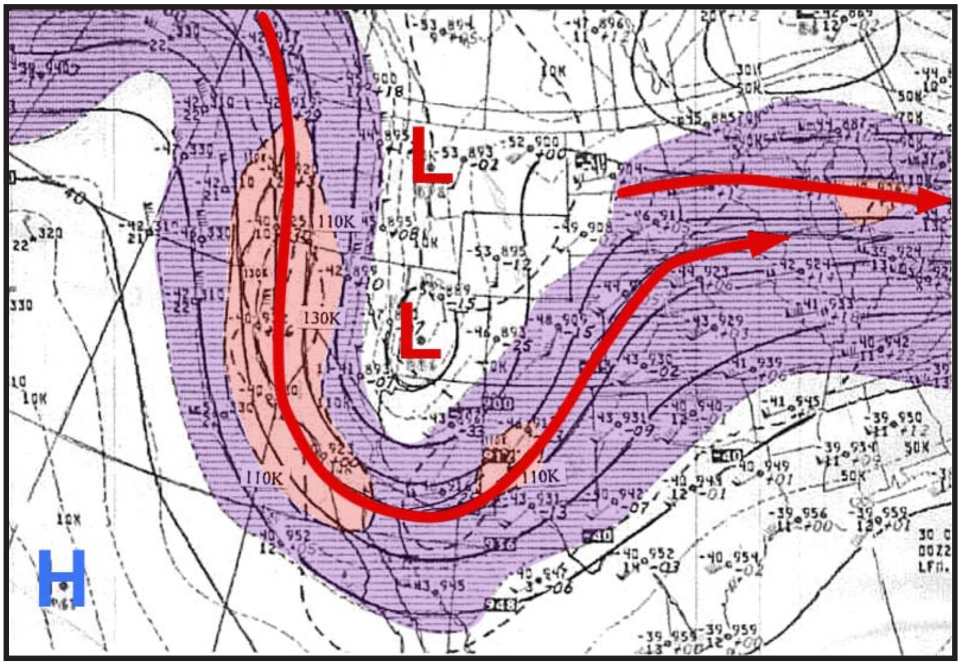

Figure 3-4. 300-mb Analysis, 0000Z/26 November 1983

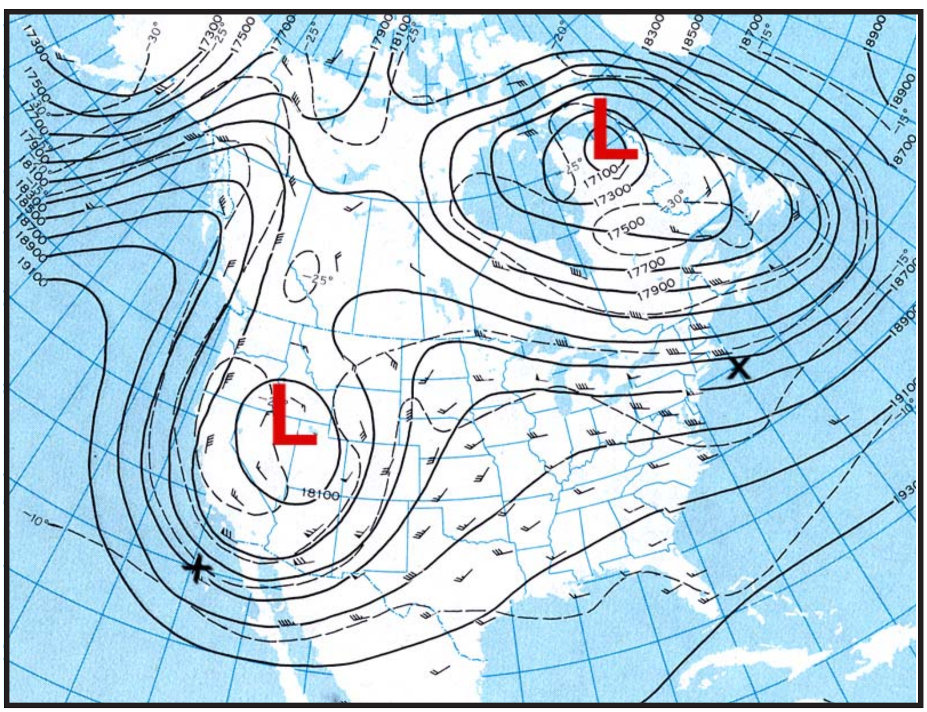

Figure 3-5. 500-mb Analysis, 1200Z/15 October 1980

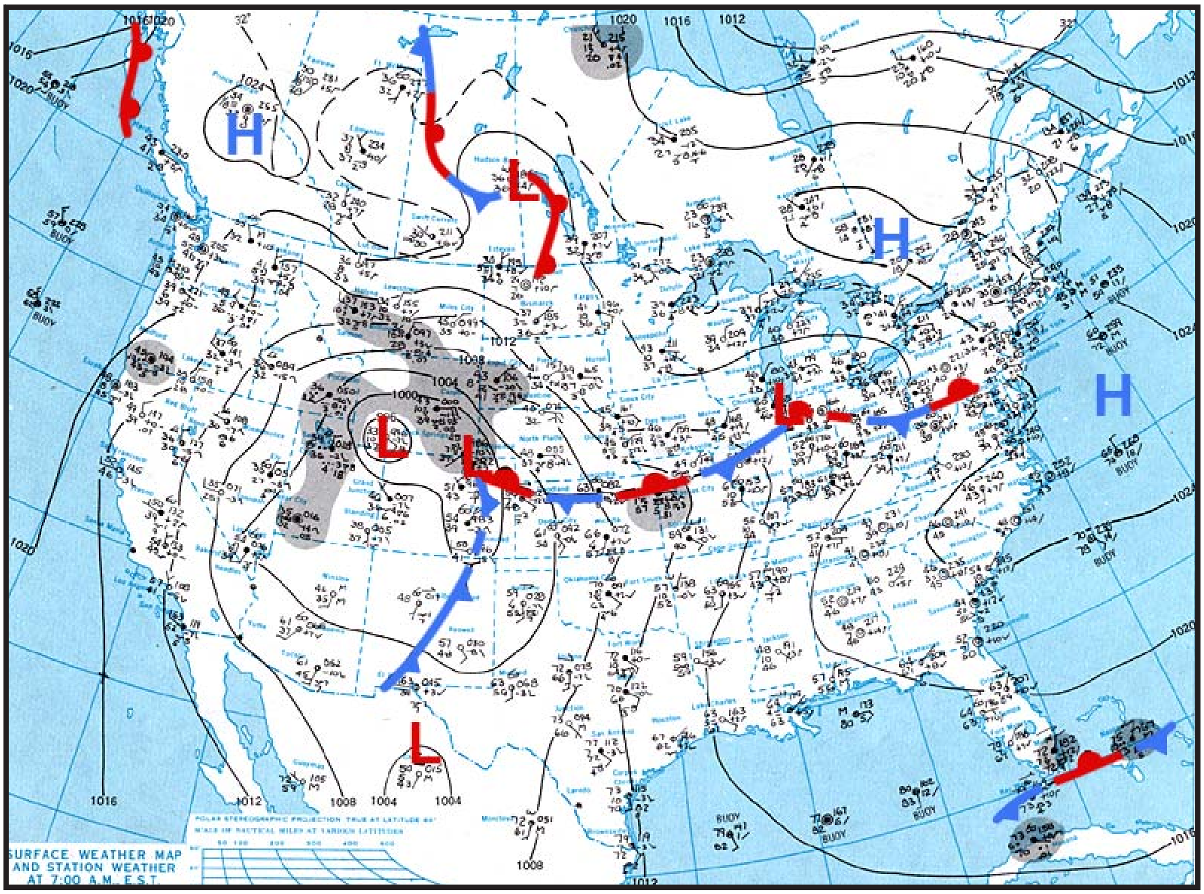

Figure 3-6. Surface Analysis, 1200Z/15 October 1980. Low-pressure system covers a large region of the western United States. Shaded areas are precipitation areas.

The developing upper low regime shown in Figures 3-1 through 3-5 is responsible for widespread precipitation events over the central and northern regions of the western United States as shown in Figure 3-6. Eventually these developing storms may produce significant storms over the central United States. More information regarding the development and tracks of western United States storm systems is presented in Winter Regimes.

Storm systems that either develop or are in the occluded stage over the eastern Pacific often affect

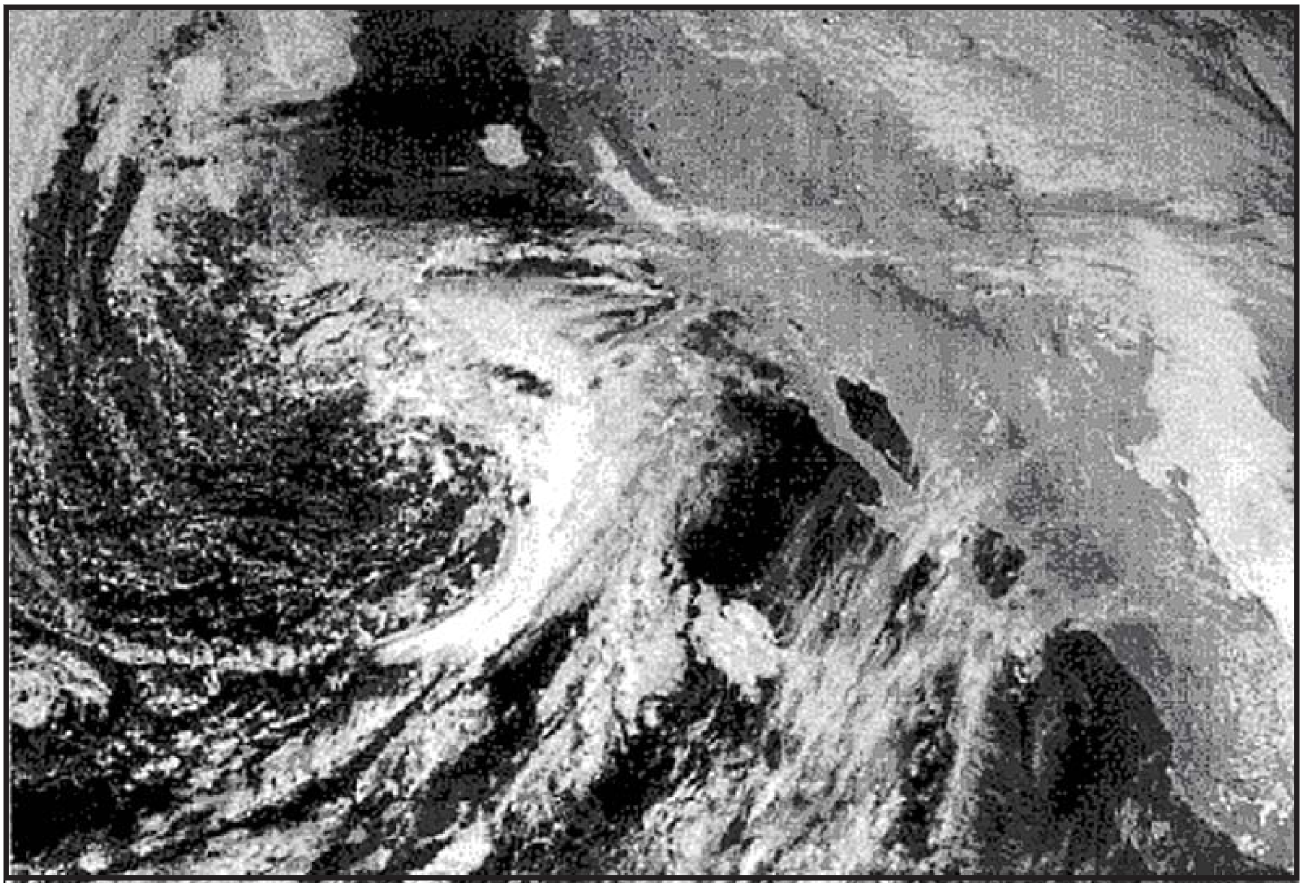

Figure 3-7. GOES West Visible, 2045Z/05 December 2000.

the coastal regions with significant rainfall and perhaps strong surface winds by November. Figure 3-7 depicts an early December short wave storm approaching the California coast.

Long Wave Troughs. The long wave trough regime was presented earlier in Chapter 2 (Figures 2-7, 2-8). It is a significant weather regime that generally occurs over the western United States during November and is shown in Figures 3-8 through 3-11. The regime reflects the changing upper air when autumn's stronger westerlies, located over the northern United States, begin to dig southward, and consequently, the upper air structure becomes a large-scale meridional trough system similar to a winter event. This particular event should be watched closely; often, organizing surface disturbances (associated with the upper system) over or west of the Rockies may not move eastward, but would remain stationary. Figures 3-8 through 3-11 depict a deepening trough and

subsequent low development over the western United States. The center of the greatest height falls indicated on the analyses is shown as an X in each illustration. The developing closed low retrogressed southwestward and settled over central California as shown in Figures 3-10 and 3-11. It has been observed through the years that this regime occurs at least once a year during the cold season—no current conventional and satellite data was saved for this event.

The models usually provide ample warning of major upper air changes such as those shown in Figures 3-8 through 3-11. These changes can also be detected on upper air analyses charts. Continuity on jet stream orientation and movement, 12-hour height falls center (HFC) movement and the locations of thermal trough to pressure trough are extremely useful. A height fall center that appears south or southwest of the previous 12-hour HFC indicates continued trough deepening. In the 500-mb examples (Figures 3-8 through 3-11), the HFCs moved southwestward rather than eastward; the developing upper low responded to the HFC movement and also move southwestward.

In Figure 3-9, note the location of the thermal trough offshore of Washington and Oregon (see arrow). The thermal and pressure troughs are out of phase, and most likely, deepening will continue. Significant snowfall over the mountainous area west of the Rocky Mountains would likely occur with the upper air structure illustrated in Figures 3-8 through 3-11.

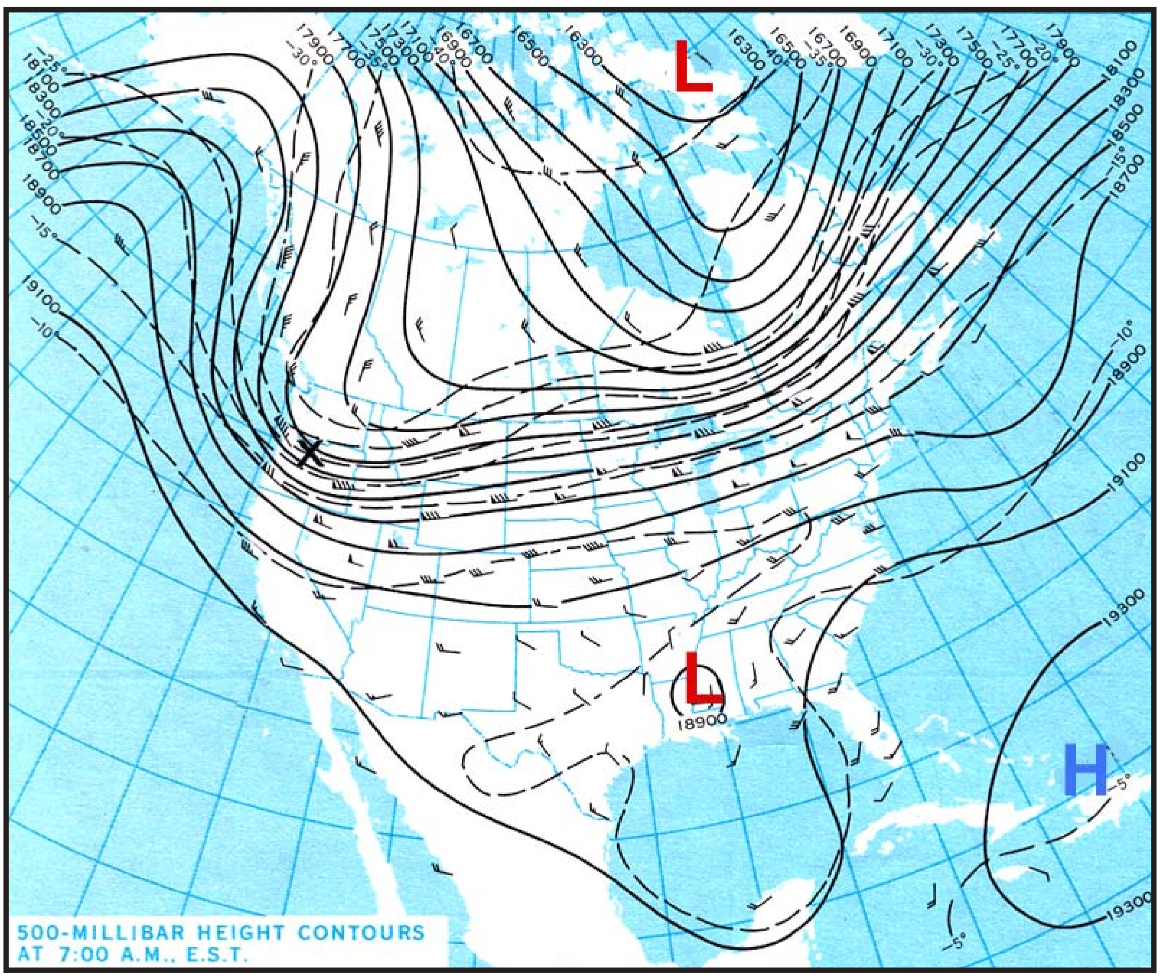

Figure 3-8. 500-mb Analysis, 1200Z/9 November 1978.

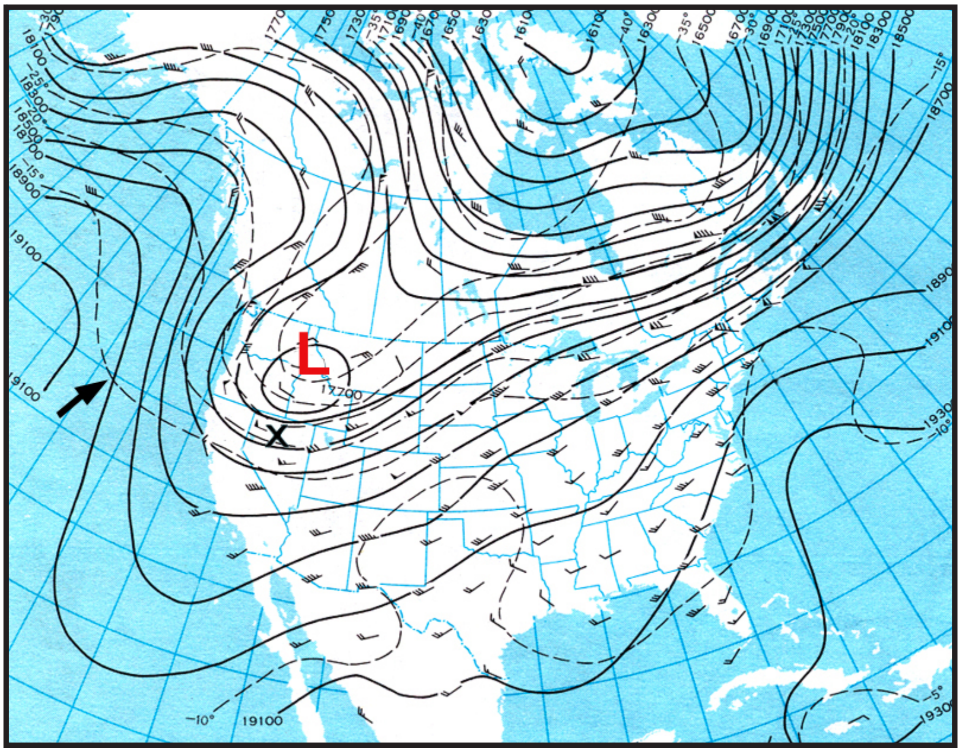

Figure 3-9. 500-mb Analysis, 1200Z/10 November 1978. Closed low appears within the deepening short wave. Arrow denotes a thermal trough west of the contour trough—an indicator of further digging.

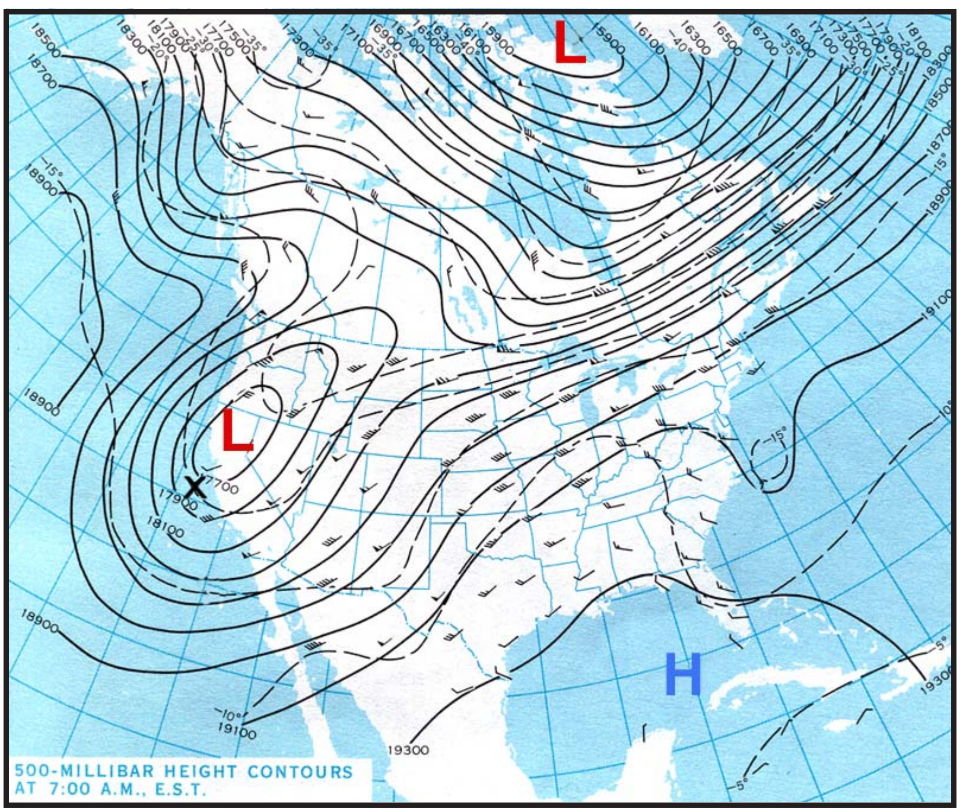

Figure 3-10. 500-mb Analysis, 1200Z/11 November 1978. Closed low (and height fall center) continues southwestward.

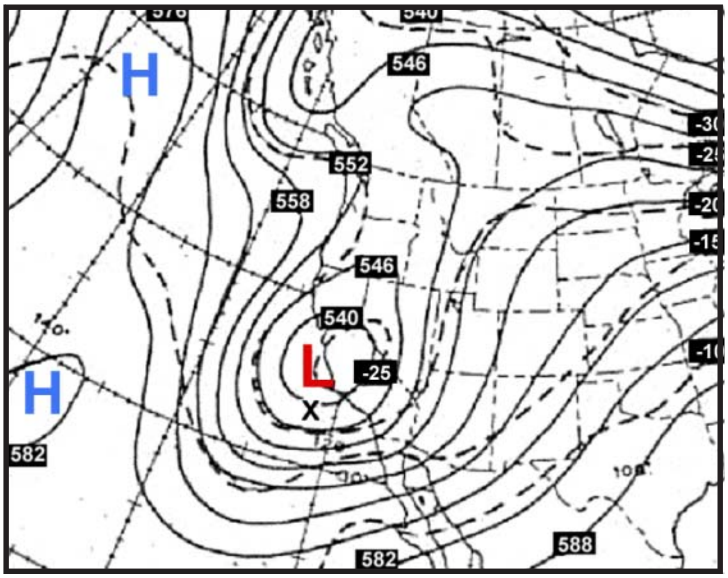

Figure 3-11. 500-mb Analysis, 0000Z/12 November 1978. Final illustration in this event shows that the low has settled off the coast of central California. These closed lows often linger for several days over southern California and adjacent ocean areas until a new impulse approaches and ejects the system eastward.

SURFACE/LOWER LEVELS.

General. The north Pacific high continues to decrease in intensity and is displaced southward to an average position of 32° N latitude by October and to 30° by November (Figure 3-12).

The thermal low that prevailed over areas of California and western Arizona during summer is displaced southward into Mexico by late summer.

Building of the Great Basin High, combined with the southerly-moving North Pacific High and the

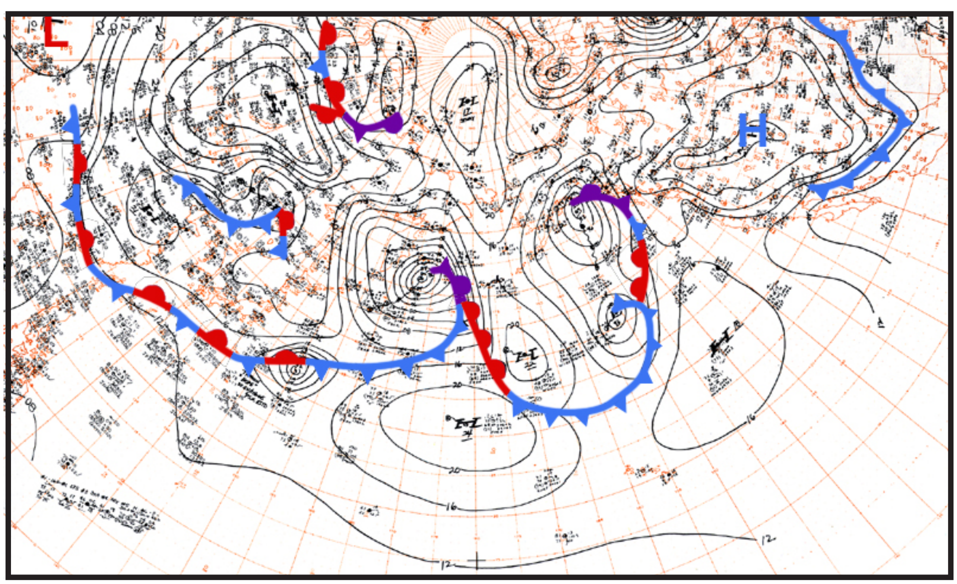

Figure 3-12. Surface Analysis, 1200Z/28 September 2001. North Pacific High gradually shifts southward and decreases in intensity.

thermal low, destroys the summer regime of onshore gradient along the West Coast. Extensive areas of low stratus that prevailed during the summer months shift southward as frontal systems approach the West Coast. Figures 3-13 and 3-14 illustrate the shrinking ocean stratus during a seven-day period.

The widespread stratus regime shown in Figure 3-13 may continue into mid-October (Figure 3-15) until the North Pacific high shifts southward and the presence of frontal systems destroys the summer's persistent low-level ridge regime.

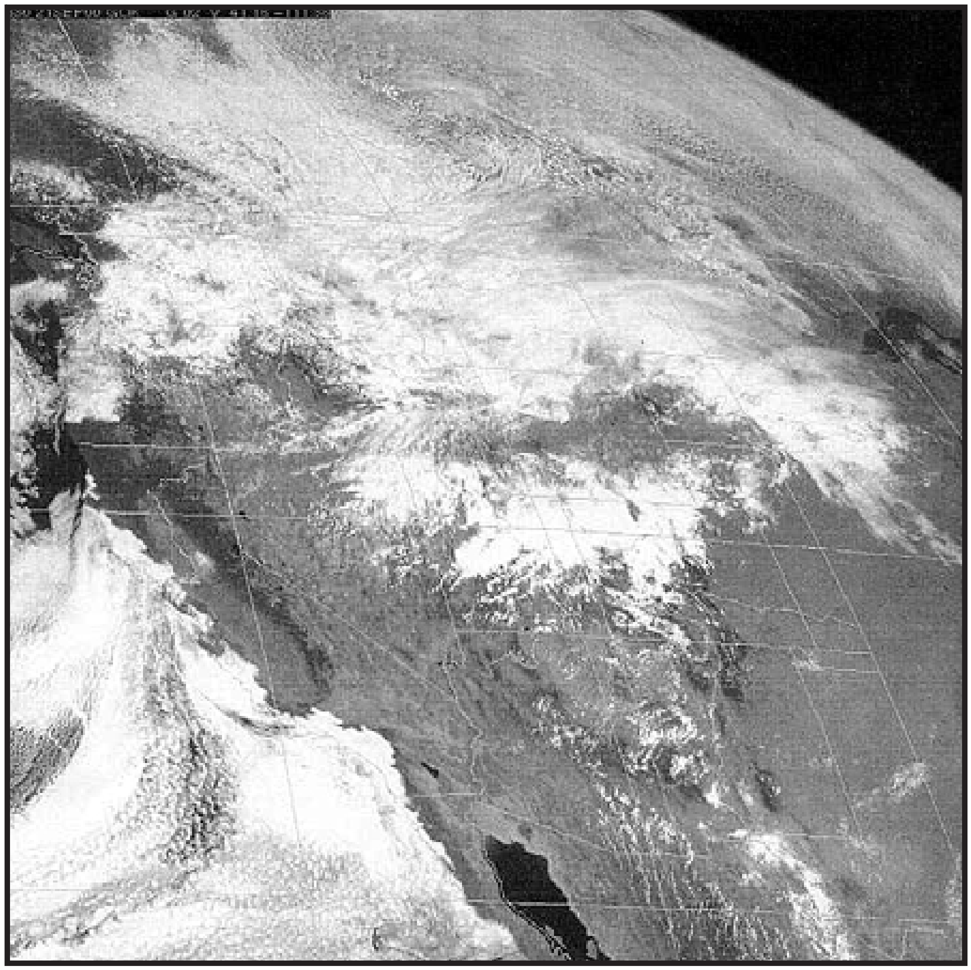

Figure 3-13. GOES West Visible, 1830Z/21 September 2000. Ocean stratus extends along the California and Mexican coastal areas at the start of autumn.

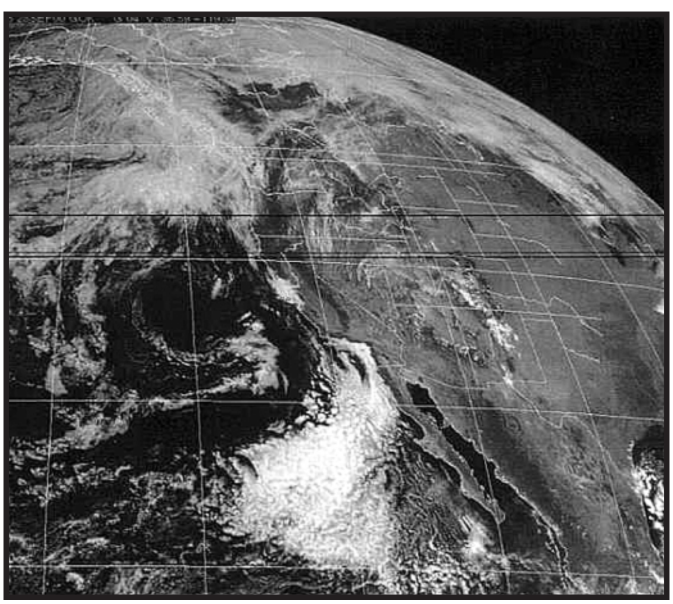

Figure 3-14. GOES West Visible, 1715Z/28 September 2000. Seven days later from Figure 3-12, the ocean stratus has shrunk as the North Pacific high migrates southward.

September is the nicest month of the year. Many western coastal stations have their lowest mean wind speed and highest mean sunshine. The warmest days of the year occur in September due to a decrease in upwelling along the West Coast and increased anticyclogenesis over the Great Basin.

September also initiates the phenomenon of "East Winds" for Pacific Coast states. These downslope winds generate very low humidity from the western valleys to the coast. Wind speeds of 25-35 knots are common; extremes of over 52 knots have been recorded. Dry east winds (called

Santa Anas in southern California) occur frequently in September, but the seasonal peak for Santa Anas is not reached until October and November. Forecasters should watch for the onset of dry east winds when a nose of the eastern Pacific high pressure cell moves into southwestern British Columbia and/or the Pacific Northwest following an active frontal passage. Synoptic pattern recognition of Santa Ana wind events will be shown under Notorious Wind Boxes. Also see Santa Ana extract in Attachment 1 of this Technical Note.

Tropical storms are less frequent in September than in August, but prevailing tracks of tropical storms are generally similar to those of August (Figure 3-16). By October, tropical storm tracks shift southward and become less frequent, and by November, tropical storms are rare. In Figure 3-16, the associated tropical

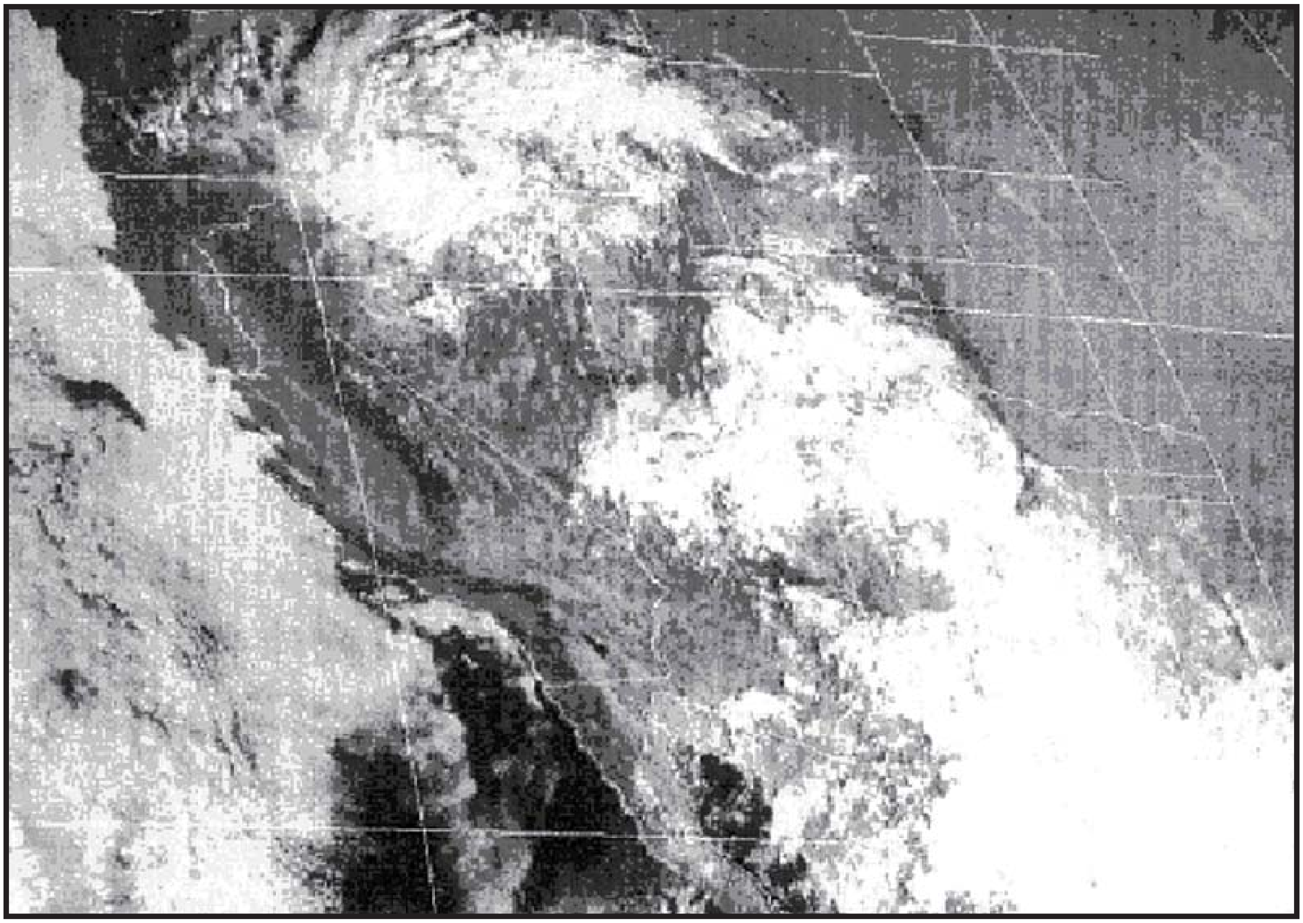

Figure 3-15. GOES West Visible, 1630Z/22 October 1998. Summer's widespread ocean stratus over the eastern Pacific and monsoon moisture over the southwestern United States may persist into mid October as shown.

moisture and instability feeder bands still poses a threat over the southwestern United States as shown by the Baja, California tropical storm tracks (see Figures 3-17 and 3-18).

Figures 3-17 and 3-18 show Hurricane Juliette that moved northward rather than westward. The hurricane was downgraded to tropical storm status when it reached northern Baja, California. The storm

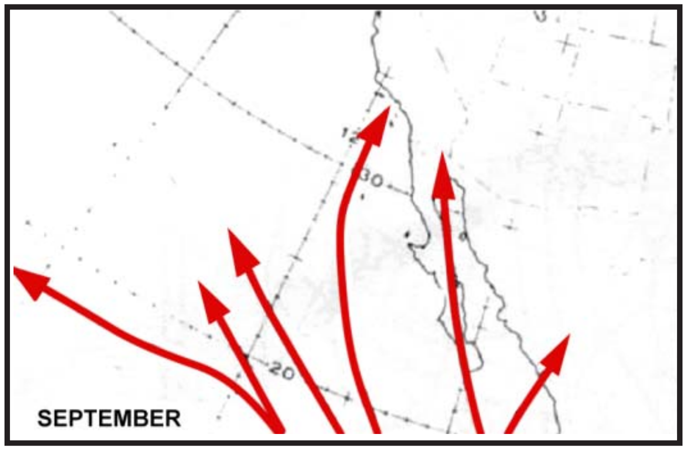

Figure 3-16. Typical September Tropical Storm Tracks.

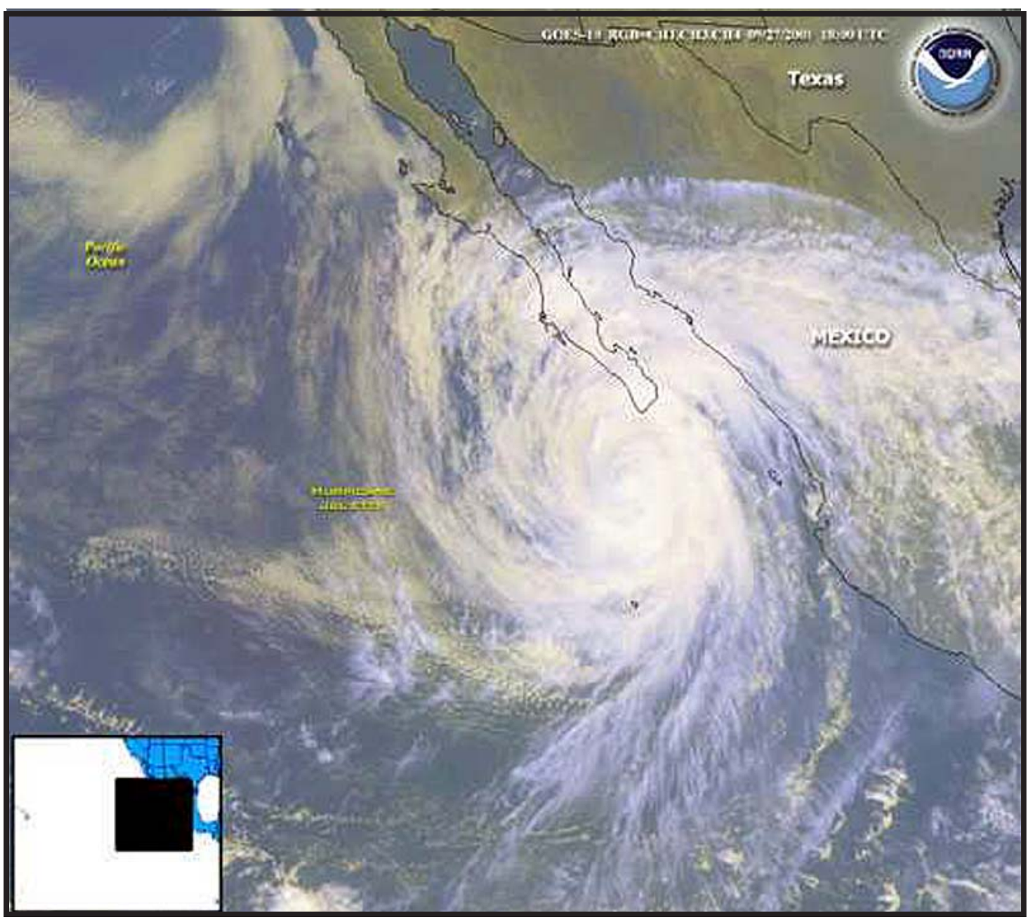

Figure 3-17. GOES West Visible, 1800Z/27 September 2001. Hurricane Juliette appears southwest of Baja, California and is moving northward.

continued to weaken as it approach southern Arizona (Figure 3-18). In Figure 3-18, cloud bands from the dissipating system can be seen across Arizona and New Mexico.

A sharp decline of the summer monsoon regime and its daily convection over the southern and central regions of the western United States occurs in early

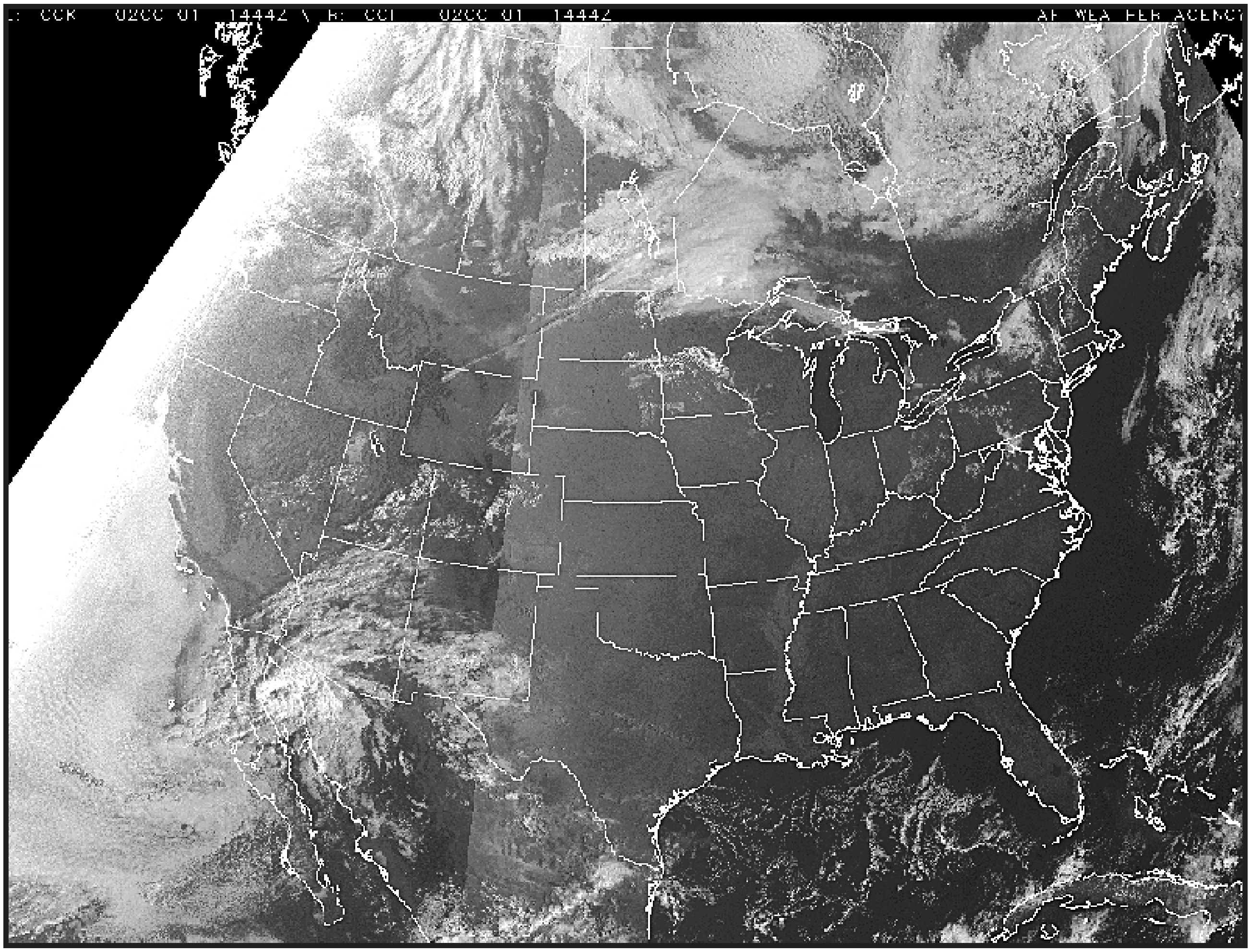

Figure 3-18. GOES West Visible, 1444Z/2 October 2001. Approximately five days later from Figure 3-17. Hurricane Juliette continued northward as it dissipated. Moisture and instability have spread into the southwestern United States.

October. Precipitation amounts decrease by 40 to 55 percent compared with August.

There is an increase in precipitation over the Pacific Northwest particularly west of the Cascades. October initiates the general rainy season that is in full swing by November as shown in Figures 3-19 and 3-20.

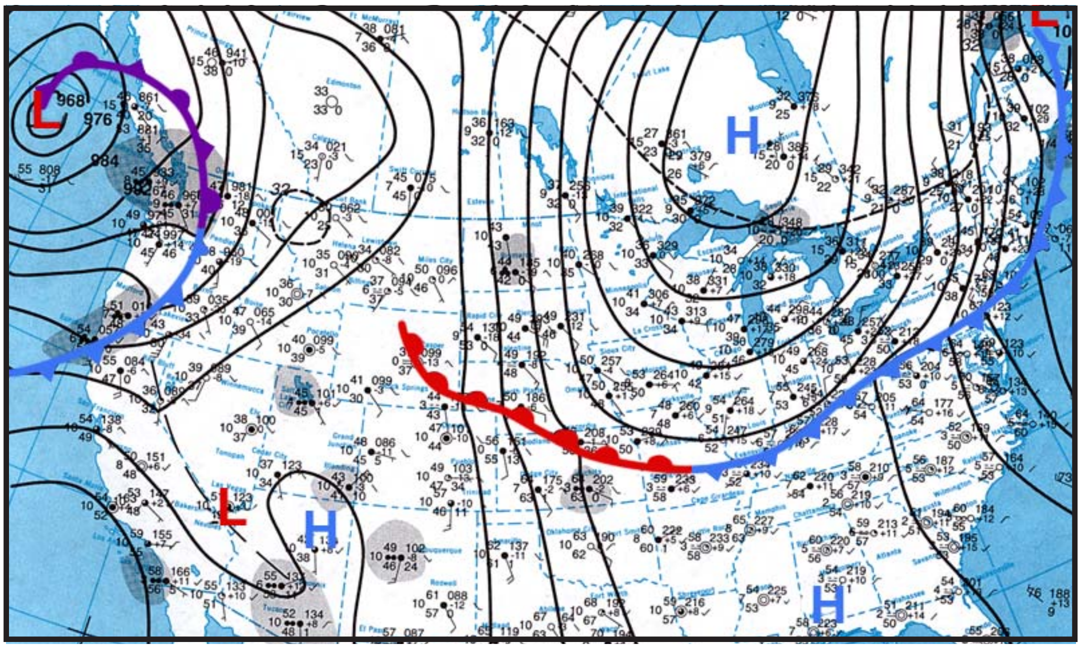

Figure 3-19. Surface Analysis, 0000Z/28 October 2000. Low-pressure systems and associated fronts shift southward and bring stormy conditions to the Pacific Northwest.

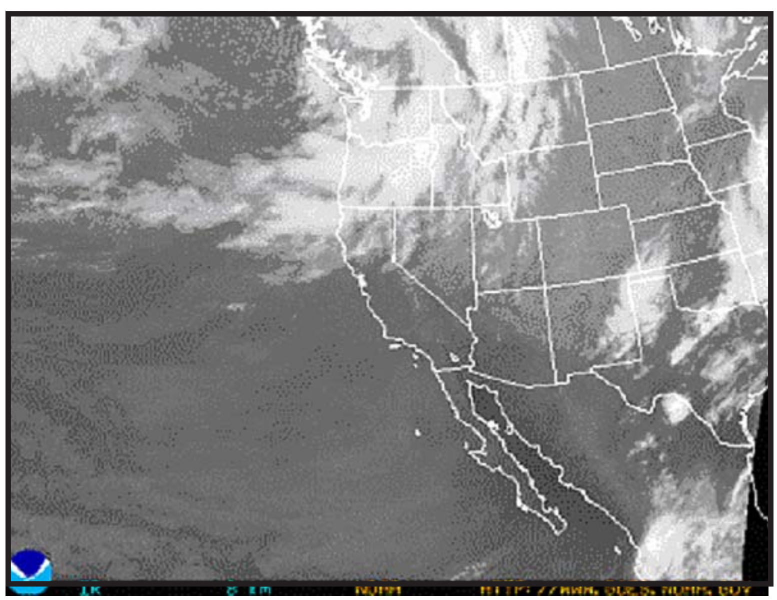

Figure 3-20. GOES West Infrared, 0300Z/11 October 2001. Cloudiness and precipitation returns to the Pacific Northwest in this early autumn event (not related to Figure 3-19).

Great Basin High

Note: Some of the information that follows was extracted from the *"Winter Regimes"* technical note, but it is appropriate to present the information within this Technical Note.

A major regime during autumn is the continued intensification of anticyclonic activity over the western United States. A persistent anticyclonic feature during autumn and winter is the Great Basin High. The Great Basin High begins to appear in September; the number of highs reaches a maximum frequency of occurrence in December. Figures 3-21 and 3-22 depict two examples.

This mountain-confined high is caused by cold air that has been trapped by the mountains (Rockies on the east and the Sierras on the west). Sea-level pressures rise as the cold air strengthens, thus the anticyclogenesis. Typical development occurs when a ridge, following a Pacific mP cold front, is pinched off the North Pacific High system along the West Coast (Figure 3-21). Persistent stratus,

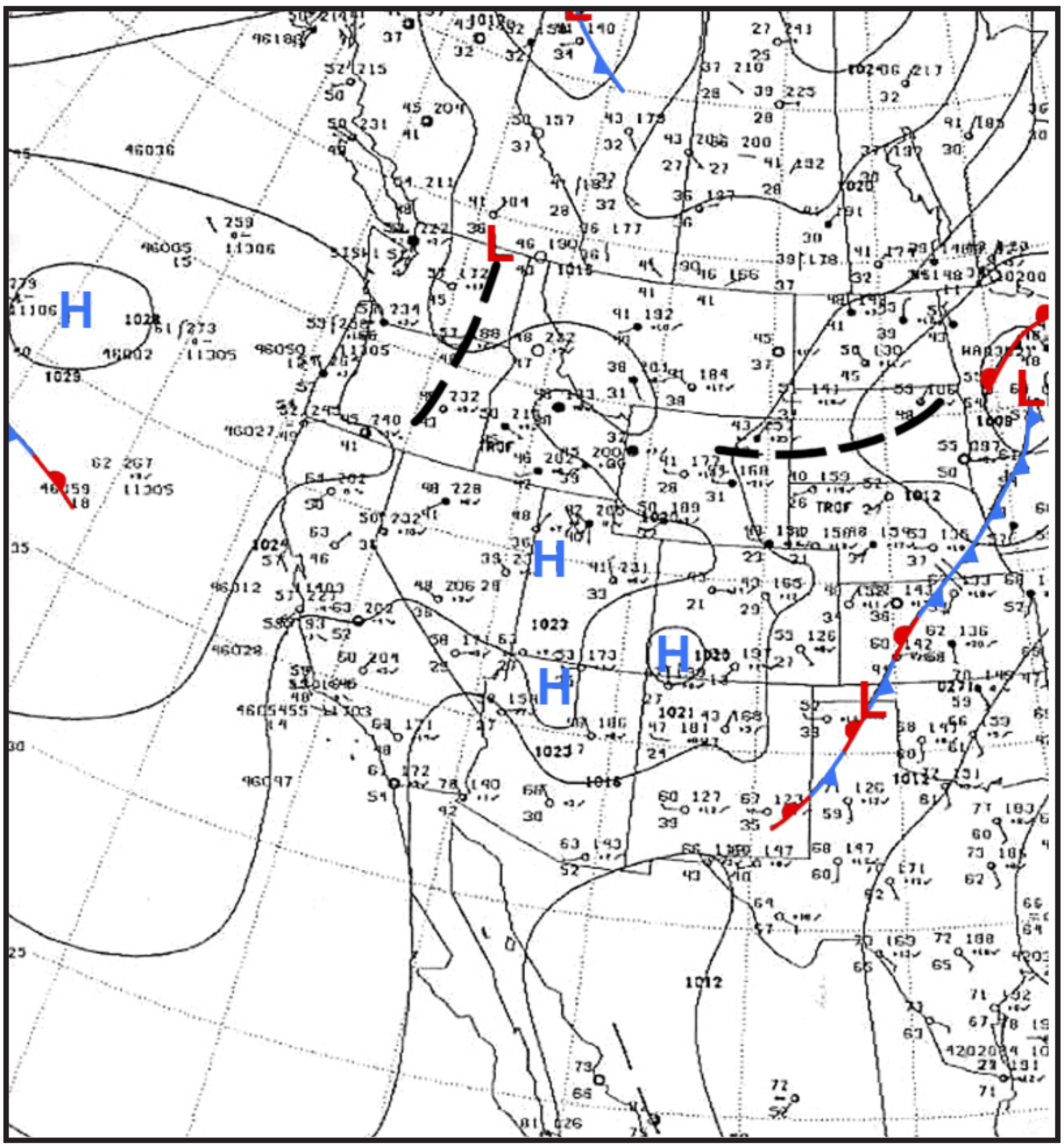

Figure 3-21. Surface Analysis, 0300Z/14October 2000. Great Basin High's air mass source is maritime polar (mP).

fog and drizzle continue to be a problem over many valley and river areas due to minimal solar insolation and a day-to-day strengthening of low-level inversions. Figures 3-21 and 3-22 depict typical Great Basin High regimes. Several highs are often analyzed on surface charts; analysts may find it difficult to analyze for very high pressures in mountain areas.

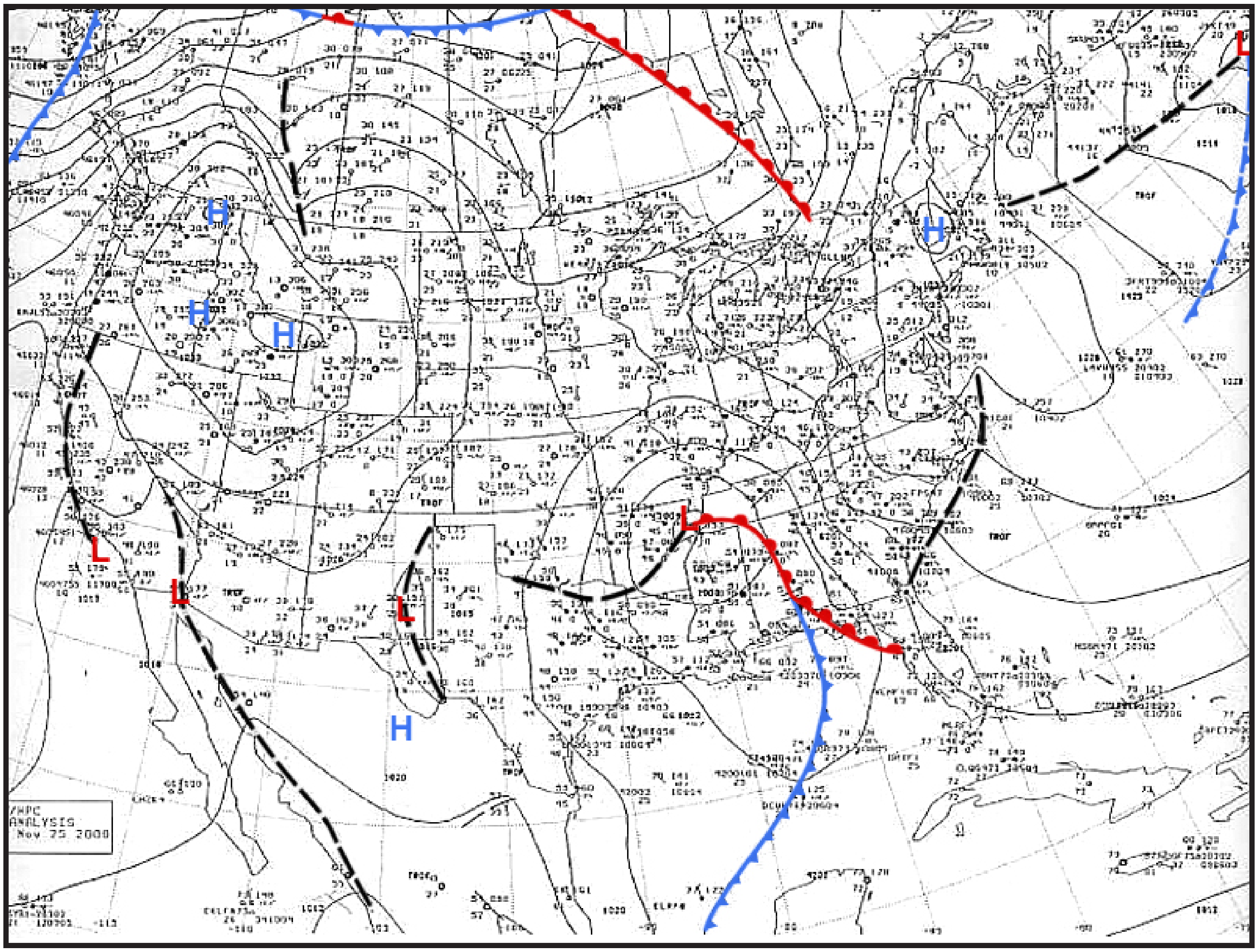

Figure 3-22. Surface Analysis, 0600Z/25 November 2000.

Great Basin Model. Figure 3-23 illustrates a Great Basin High model and the various weather phenomena associated with this annual regime. Although the weather phenomena that will be shown are primarily winter regimes, these events generally begin in November. Persistent fog in the San Joaquin and Sacramento Valley areas, low ceilings, fog and drizzle (and freezing drizzle) in the Columbia Basin and Snake River valley regions and strong warm downslope winds east of the Montana and Wyoming Rocky Mountains occur with this regime.

Quasi-Stationary Front. The quasi-stationary front shown across eastern Montana and Wyoming in Figure 3-23 appears frequently during late autumn and winter. The front separates the mountain-confined Great Basin High and transitory Canadian polar air masses. The front fluctuates back and forth across central and eastern Montana and Wyoming when frontal lows either develop over the area or drop southward from Canada bringing in fresh outbreaks of Canadian polar air. Forecasters must keep continuity on the strengths, trends and movements of these two anticyclonic systems to determine frontal locations and expected weather conditions. Distinct weather events occur on either side of the frontal zone as will be shown in the subsequent pages.

A second Great Basin High regime occurs when continental polar (cP) ridging from western Canada drops southward and westward (typically an Alberta High) across the Pacific Northwest and merges with maritime polar (mP) already in place over the Great Basin area (not shown). It is important to **recognize the source region** of the Great Basin High to determine the strength and persistence of low-level inversions (stratus, fog and freezing drizzle).

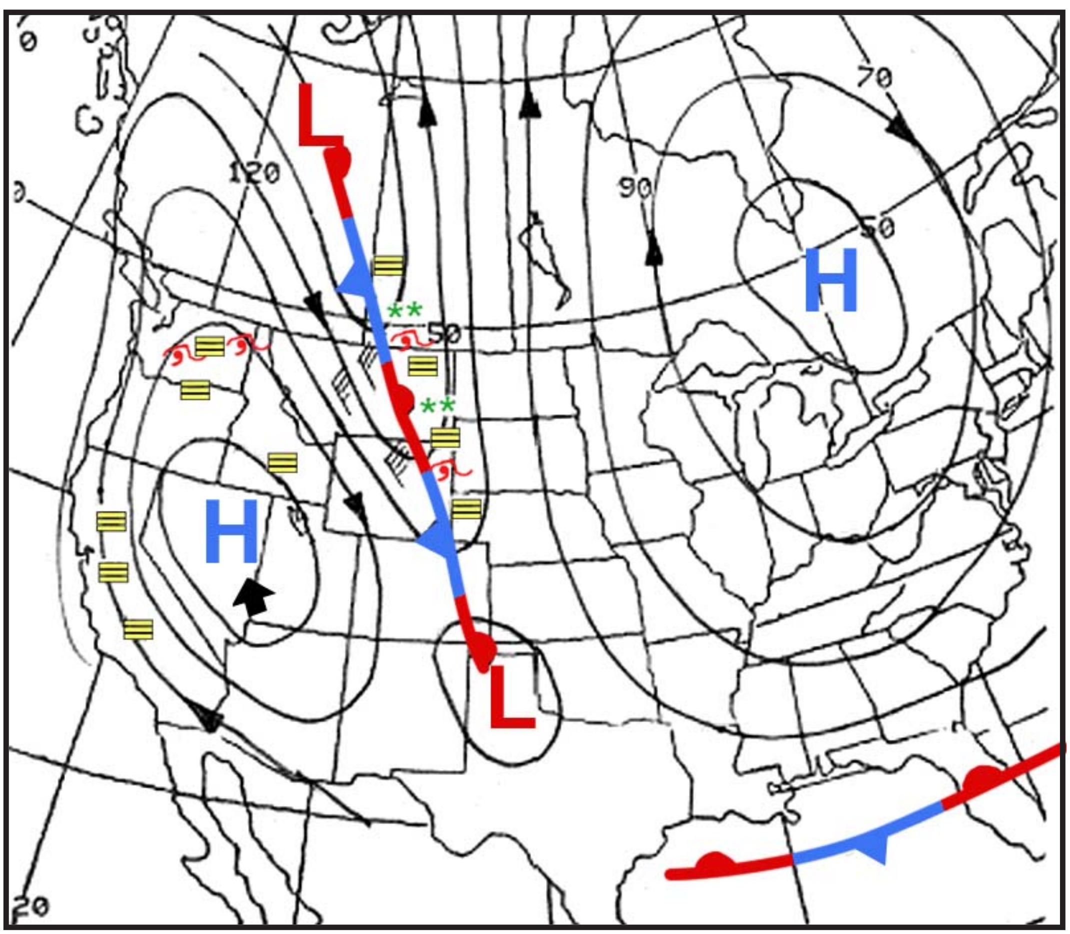

Figure 3-23. Great Basin High Model

FOG REGIMES – WESTERN UNITED STATES

San Joaquin and Sacramento Valley Fog Regimes. A stratus and fog regime often begins during November within the San Joaquin and Sacramento Valleys of central California as the Great Basin High builds (Figure 3-24). Generally moist maritime polar air advects eastward into the valley regions where the moisture is not blocked by mountain ranges. The San Francisco/Travis AFB area, as shown in Figure 3-25 (noted by the arrow), is an example of such valley regions. This early morning photo (Figure 3-25) shows an excellent example of marine stratus that has funneled into the San Joaquin Valley from the San Francisco area.

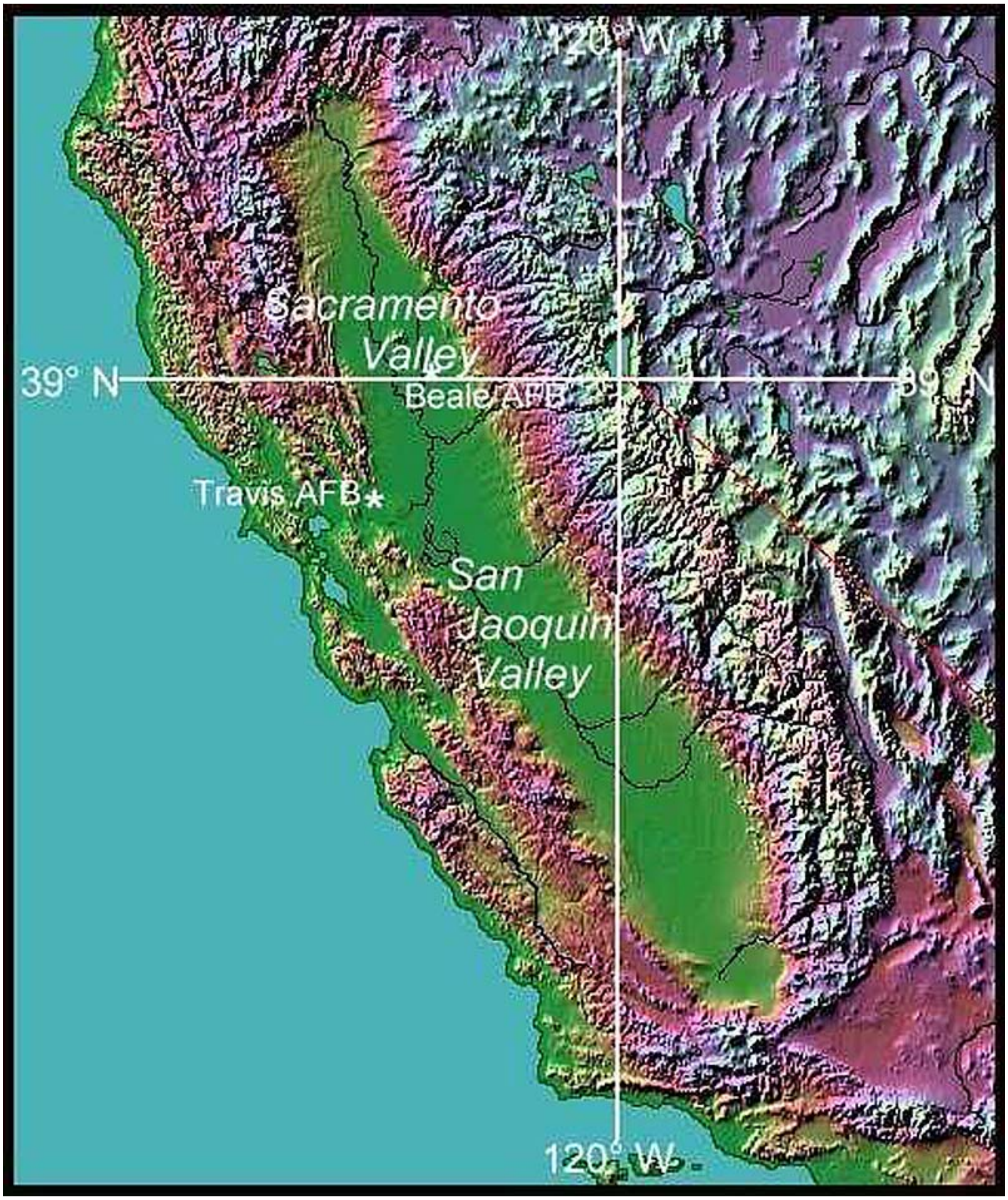

Figure 3-24. San Joaquin and Sacramento Valleys. Note the elongated "bowl" in interior California surrounded by mountains. It's easy to see why there can be "trapped" persistent fog.

In Figure 3-25, the inland stratus dissipated with surface heating; however, during the cold season, the inversion strengthens. Consequently, stratus/fog will persist for long periods during the cold season. Figure 3-26 typifies a visible satellite picture of this regime. This fog regime will continue daily for days until the Great Basin High dissipates or shifts eastward in response to warm air advection ahead of an approaching Pacific storm system.

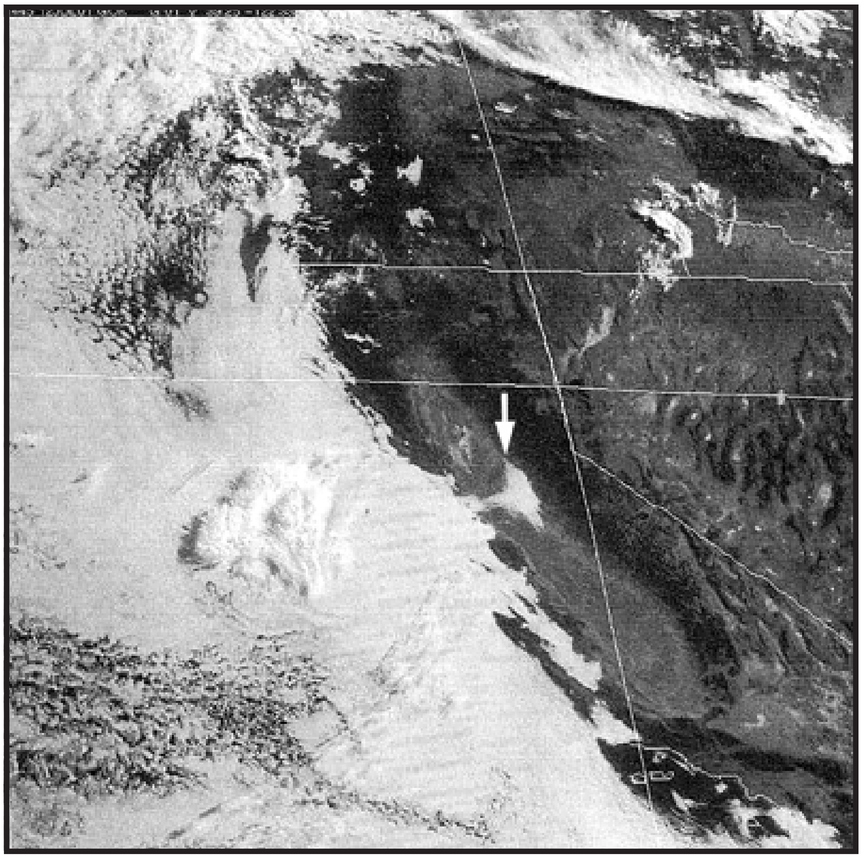

Figure 3-25. **GOES West Visible, 1445Z/12 July 2001.** Although this not an autumn photo, it is included to show Pacific stratus advection into the San Joaquin Valley.

Columbia Basin

The Columbia Basin area east of the Washington Cascades (Figure 3-27), may experience continuous days of low ceilings, fog and drizzle

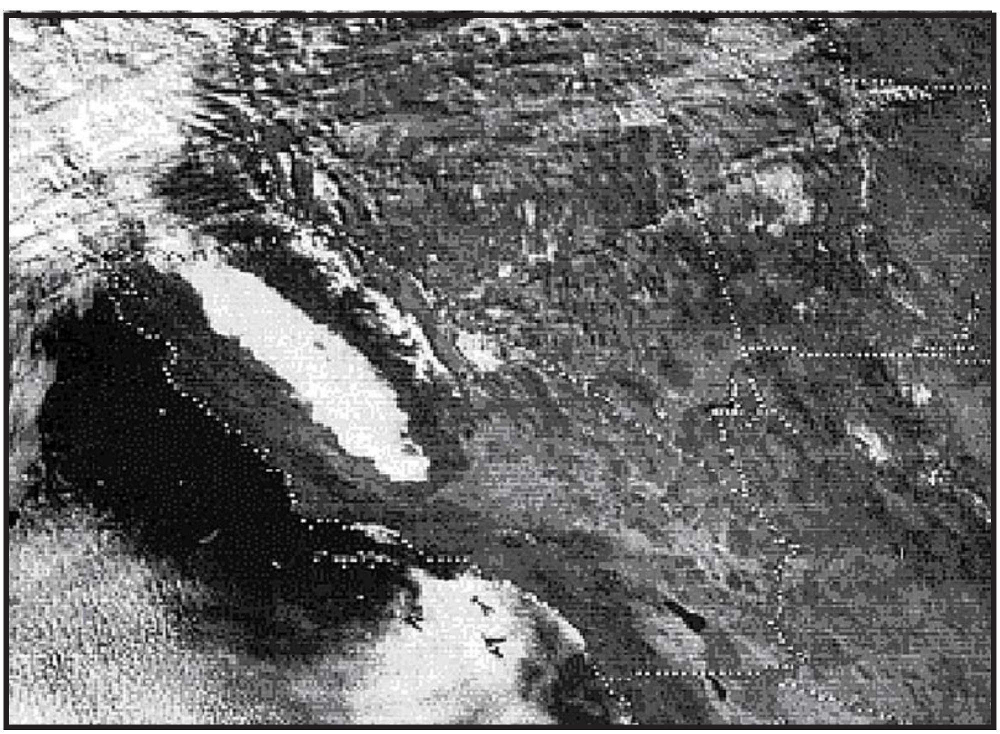

Figure 3-26. Typical Stratus Regime. This is a winter picture but it is included to alert forecasters that this event often begins in November.

when a cP ridge, extending northward from the Great Basin High, lies across the basin. This event is a winter regime; however, it generally begins in late November. When the source region is continental Polar air from western Canada, the inversion becomes very strong and "traps" low-level moisture in basins and valleys. The high will persist for days until there is an air mass change. Freezing drizzle is generally a common diurnal event

The final regime, associated with the Great Basin High (Figure 3-23), is strong westerly downslope winds over the northern Rockies. This event will be presented in Notorious Wind Box that follows.

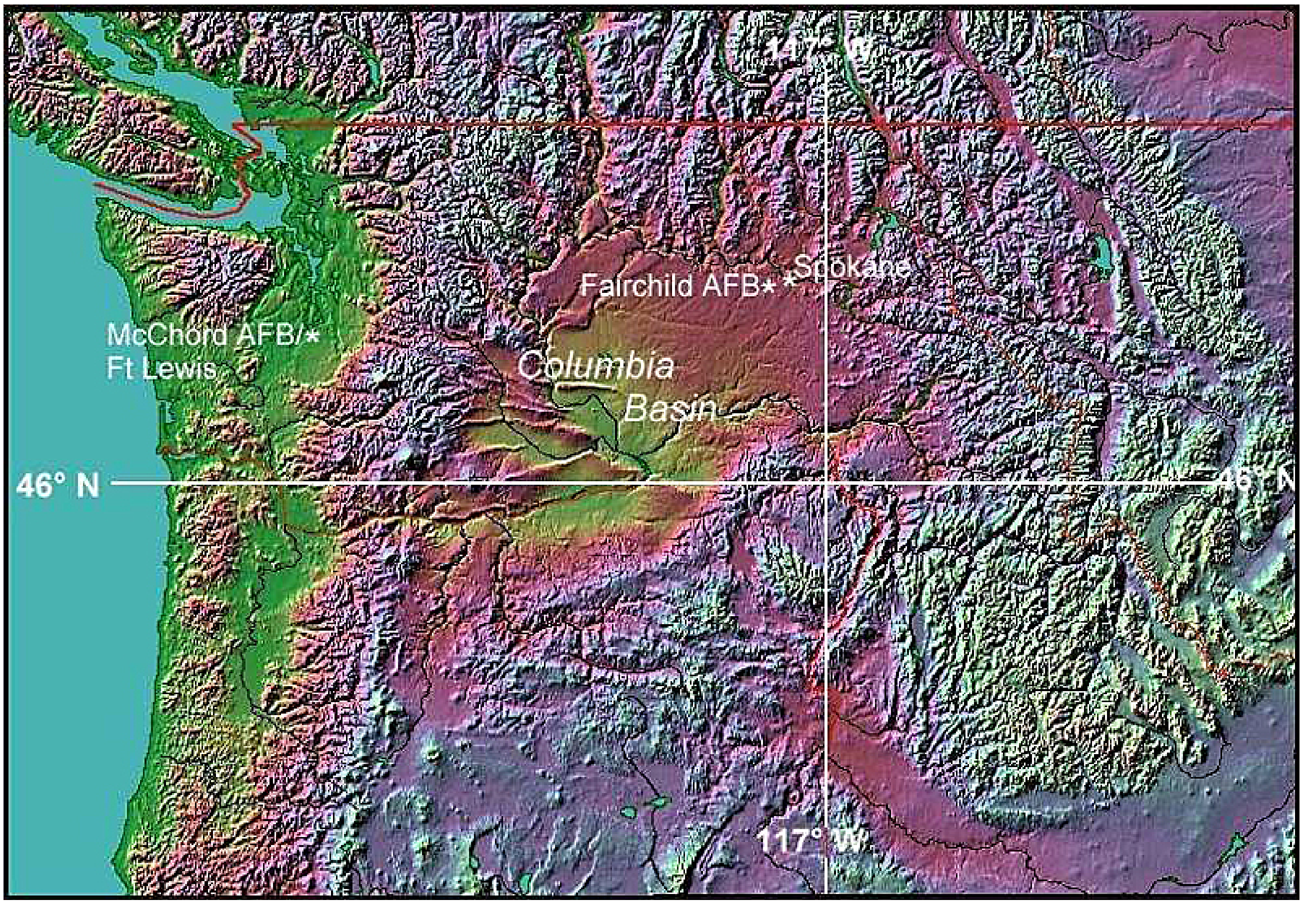

Figure 3-27. Topographic Map of the Columbia Basin. Spokane and the Fairchild AFB area experience many days with persistent fog and stratus.

NOTORIOUS WIND BOXES – WESTERN UNITED STATES

Forecasting strong non-convective surface winds over the western United States is a challenge that begins in late autumn. Coastal and mountain areas have a strong influence on the strength of surface winds. In addition, Pacific upper troughs often undergo changes across the mountains from the Cascades/Sierras to the Rockies due to terrain effects. Deepening troughs result in surface cyclogenesis in mountain areas that may produce strong orographic and gradient winds. Strong, cold- air advection winds (greater than or equal to 35 knots), can occur anywhere over the western United States when conditions are favorable. There are, however, several "notorious" wind areas (boxes) identified over the United States that are included in this technical note. Figure 3-28 shows these Notorious Wind Boxes, which begin in late autumn and continue through winter. Only the Northwest Pacific, Livingston and Los Angeles (Santa Ana) wind boxes will be shown; the remaining wind boxes shown are mostly winter events.

Pacific Northwest Box. The Northwest Pacific Box is associated with major storm tracks (Figure 3-29). When large-scale storm systems move through the eastern Pacific on a course towards the Pacific Coast between 40° and 50°N latitude, strong winds begin within the box shortly before the system's arrival and

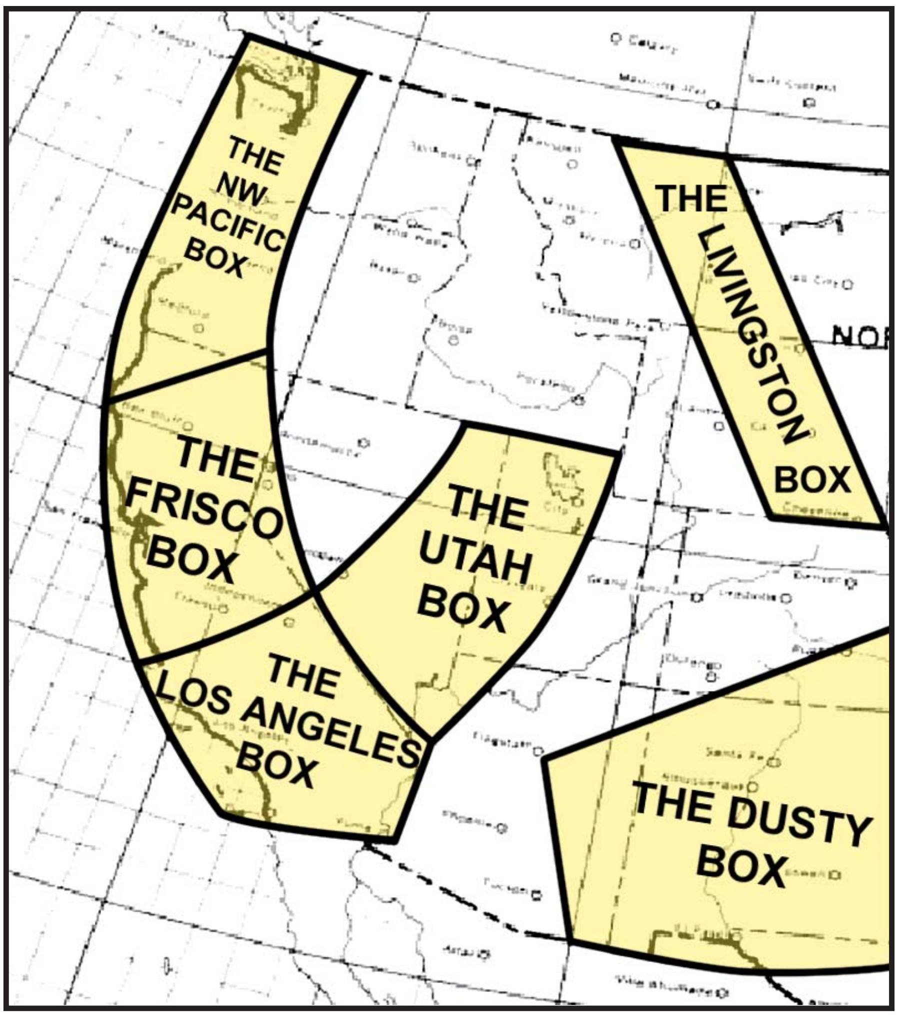

Figure 3-28. Notorious Wind Boxes - Western United States. Map depicts areas frequently affected by strong non-convective surface winds (greater than or equal to 35 knots) across the United States.

may continue for a period of up to 24 hours. Figure 3-30 depicts coastal reporting stations affected by strong winds. Hourly buoy reports are available over the ocean areas. Figures 3-31 shows an example of strong isobaric gradients over the Pacific Northwest that would generate strong surface winds.

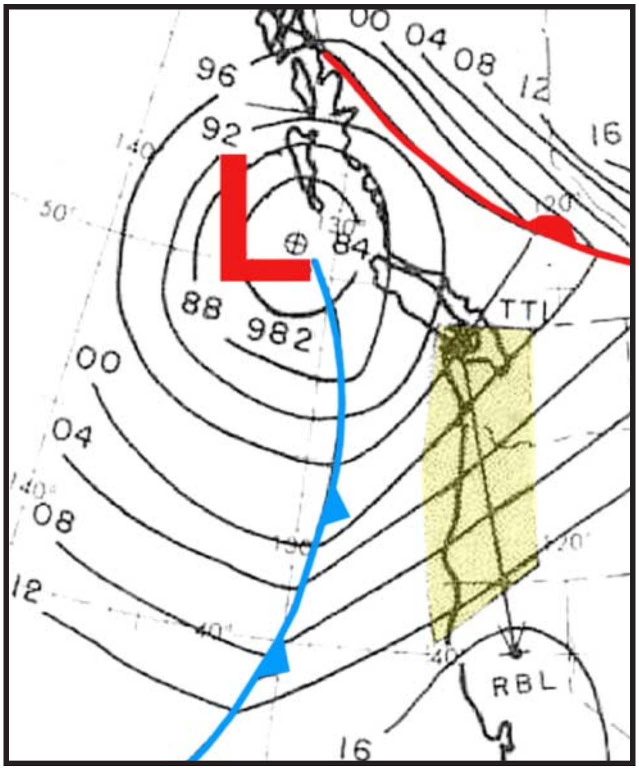

Figure 3-29. Northwest Pacific Box.

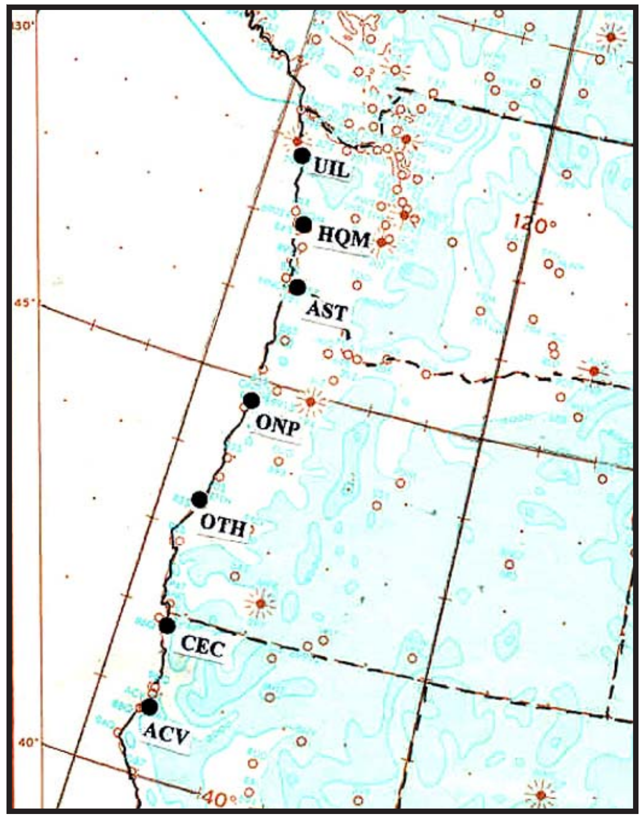

Figure 3-30. Stations in the Northwest Pacific Box

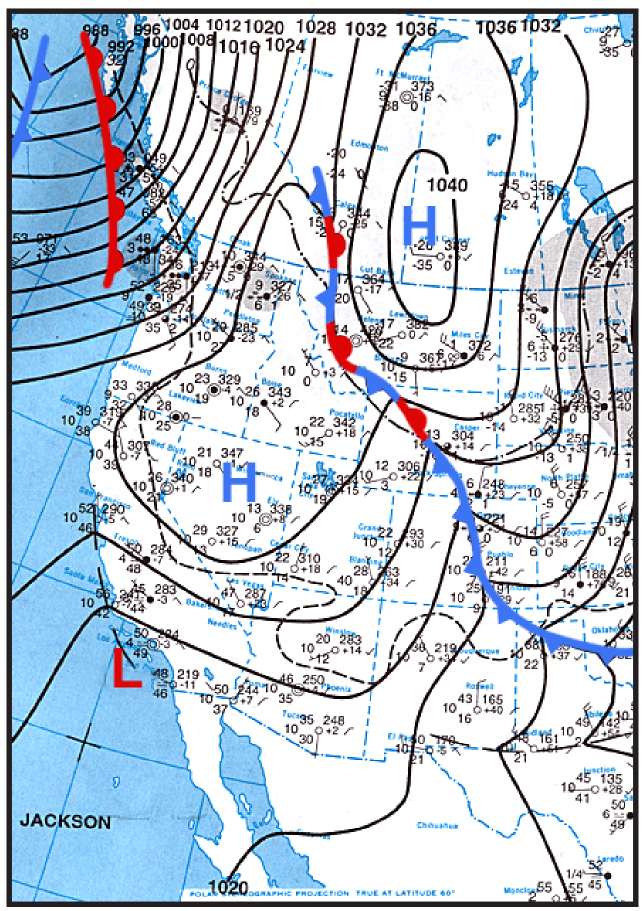

Figure 3-31. Surface Analysis, 1500Z/16 December 2000. Tight pre-cold frontal pressure gradient will produce strong winds along the Washington and Oregon coast.

Livingston Wind Box (Chinook Winds). The Livingston wind regime, which is the most active event during autumn, occurs when the polar jet shifts southward. Canadian and Northern Rockies low-pressure systems, associated with the polar jet, often produce strong pressure gradients. Additionally, the lee-side trough, east of the Montana to Colorado Rocky Mountains, in conjunction with the Great Basin High plays an important role in establishing these strong winds (Figure 3-32). The pressure gradient between these two synoptic regimes provides an excellent forecasting tool for forecasting the strength of chinook winds. Malmstrom AFB and Great Falls, Montana, which are located within the Livingston Box, have excellent rules-of-thumb for forecasting strong winds.

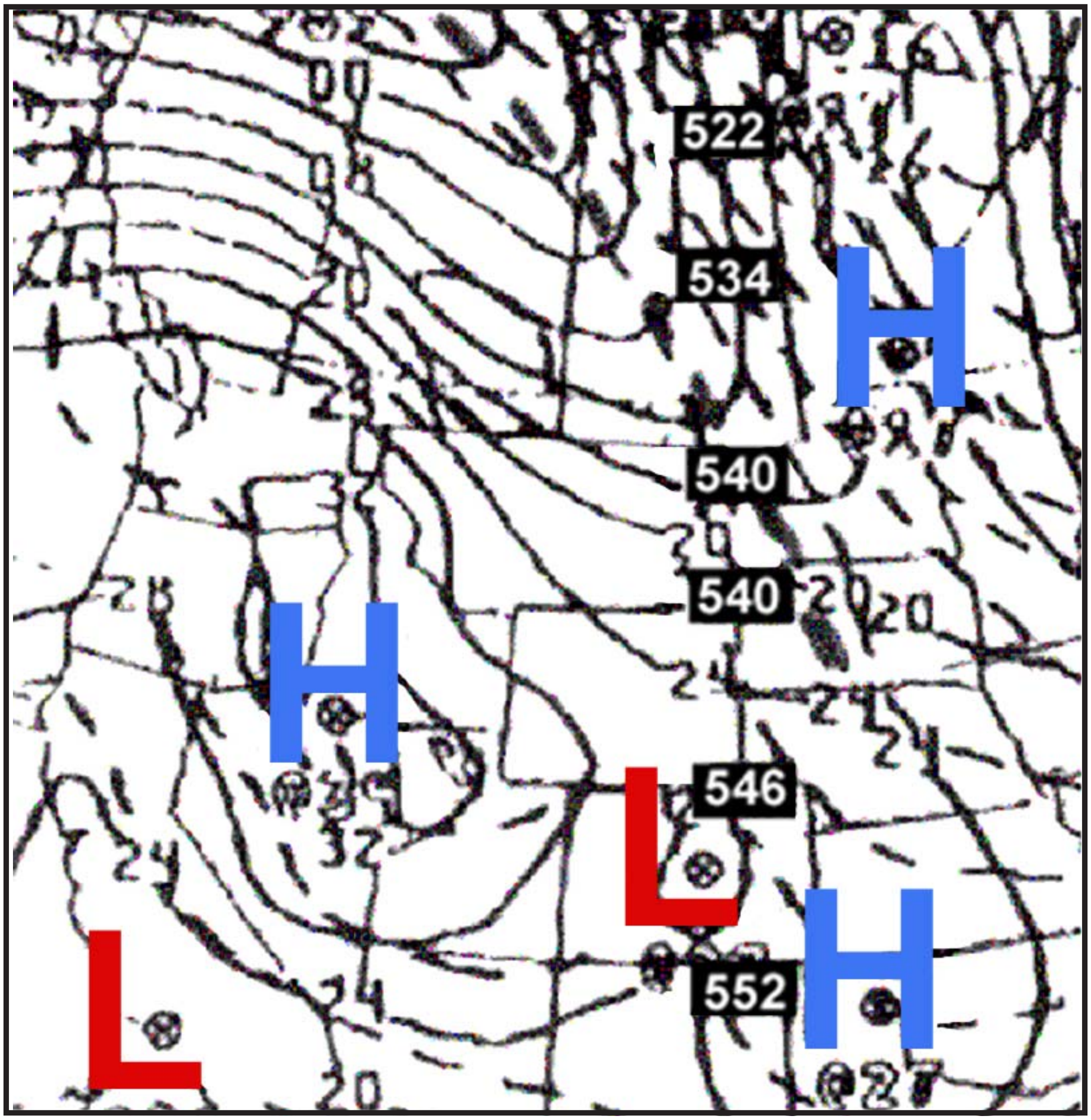

Figure 3-32. Mean Sea-Level Pressure/1000- to 500-mb Thickness, 0000Z/20 November 1993. Trough shown east of the Rockies and the Great Basin High in place over northern Nevada.

Figure 3-33 shows typical surface wind reports east of the Montana and Wyoming Rocky Mountains (downslope).

Figure 3-34 shows the reporting stations affected by strong, Chinook winds. The Livingston, Montana (LVM) region is notorious for strong winds that may continue for several days and do not let up (less than 35 knots) during the radiational cooling period. Sometimes, the Livingston Box will extend southward into northern Colorado and will affect the Denver (DEN) and Boulder (BJC) locations.

Livingston Box wind directions are from a southwest component; cold air advection wind directions are from a northwest component. The strong southwest surface winds decrease in strength as they move away from the mountains (only Livingston Box winds; cold air advection winds will continue eastward).

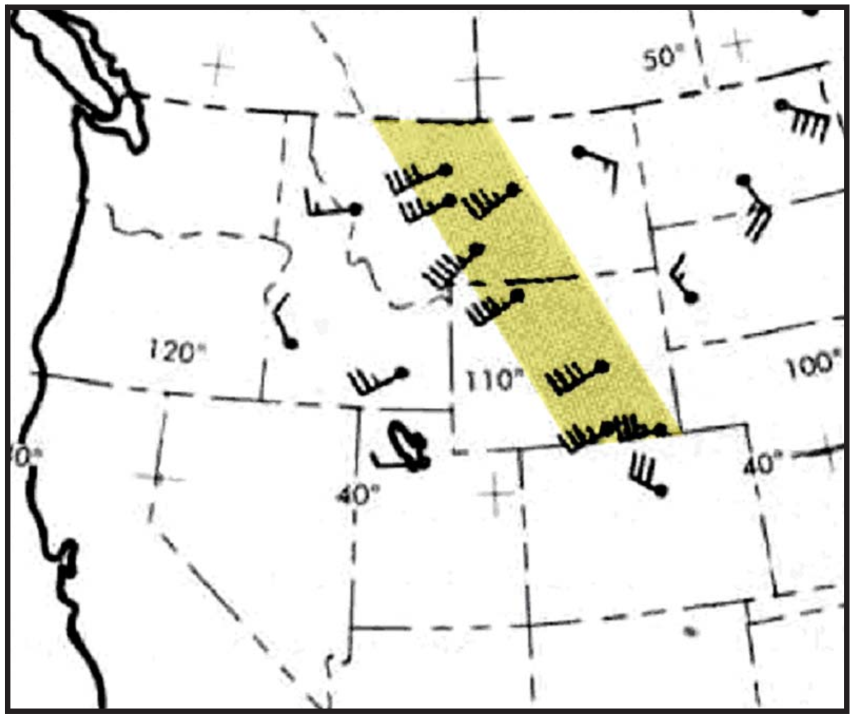

Figure 3-33. Livingston Box.

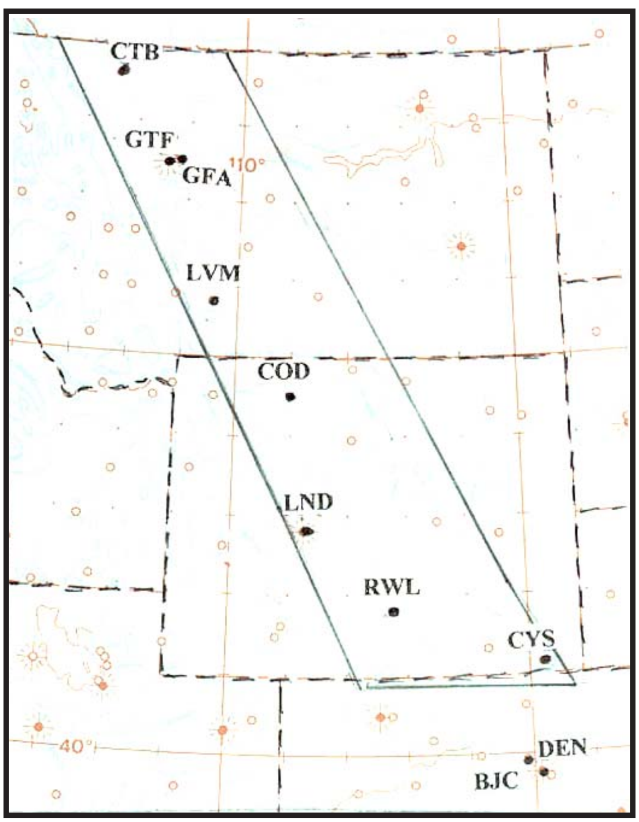

Figure 3-34. Stations in the Livingston Box. Reporting stations affected by strong chinook winds.

There are several synoptic patterns that produce strong Chinook winds east of the mountains. One of the more common synoptic pattern is associated with strong mid- to high-level westerly winds that are brought to the surface due to surface heating, negative vorticity advection (NVA) and mountain downslope. Figures 3-35 through 3-37 illustrate one of these events.

In the morning upper-air charts, (Figure 3-35), 60 to 70 knots are shown within the Livingston Box at the 300-mb level. At the 700-mb level (inset) the range is from 10 knots at Landers, WY to 25 knots at Great Falls, MT.

In Figure 3-36, 12-hours later, the late afternoon plots continued to show wind speeds greater than or equal to 35 knots at the 700-mb level (inset) over the Livingston Box area. Figure 3-37 shows surface wind reports between 19-20 November 1993 that equal or exceeded 35 knots.

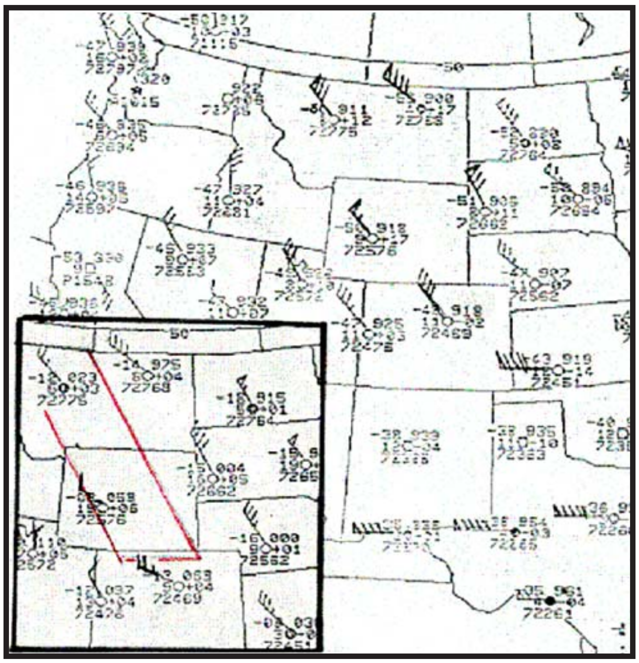

Figure 3-35. 300-mb Analysis, 1200Z/19 November 1993. Inset: 700 mb, 1200Z/19 November 1993. Fifty- to Sixty-knot jet max is shown over the Livingston Box region at the 300mb level. The 700-mb winds within the box (red area) are less than or equal to 25 knots.

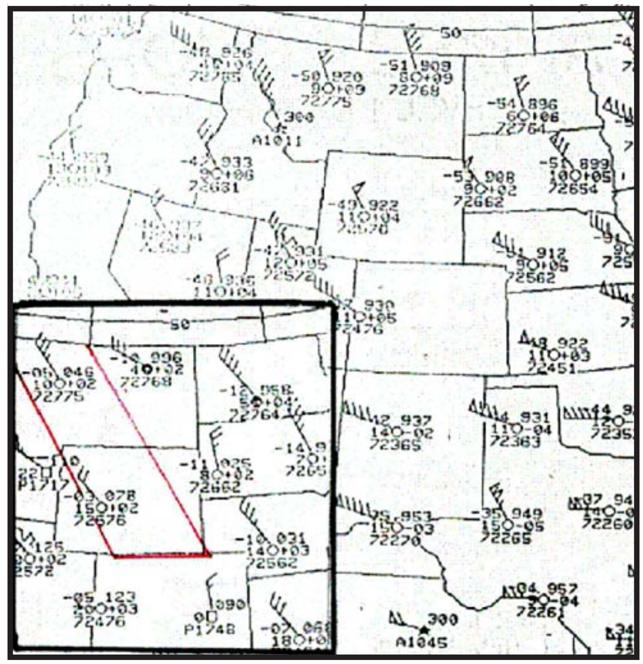

Figure 3-36. 300-mb Analysis, 0000Z/20 November 1993. Inset: 700 mb, 0000Z/20 November 1993. Twelve hours later from Figure 3-35. The evening upper air plots show wind speeds greater than or equal to 35 knots over the Livingston Box region.

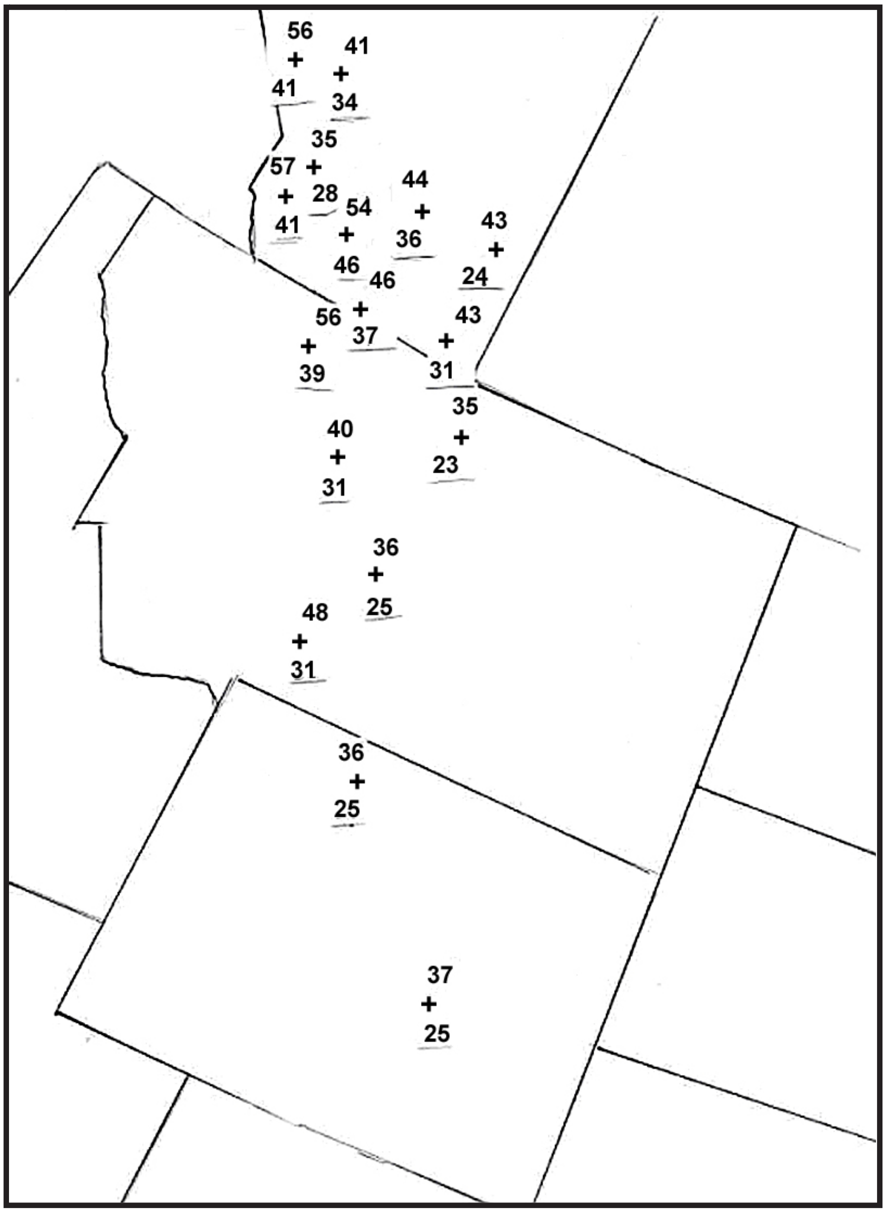

Figure 3-37. Surface Wind Reports, Livingston Box, 19-20 November 1993. Surface winds reported greater than or equal to 35 knots. Top numbers: Maximum gust Lower numbers: Sustained wind

Los Angeles Box

Los Angeles Box – Example 1. Two synoptic patterns that produce strong northwesterly to northerly surface winds are shown in Figures 3-38 and 3-39. The wind regime that is shown in Figure 3-38 is mostly a winter event but may occur in November. In Figure 3-38, strong northwesterly downrush winds associated with a digging upper trough occurred following cold frontal passage. Surface pressure gradients are not always very tight over California and that may mislead forecasters that strong westerly winds will not occur.

Los Angeles Box – Example 2 (Santa Ana). The Santa Ana wind regime is a feature that generally begins in late September and/or early October and continues through mid-winter when developing lows appear within deepening troughs over the southwestern United

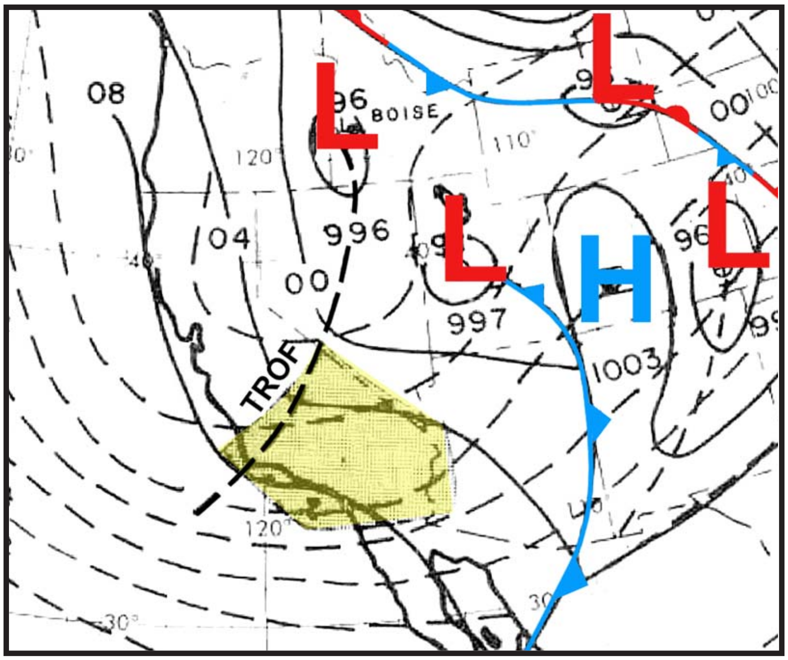

Figure 3-38. Los Angeles Box Surface Example 1. Shaded area represents strong surface winds.

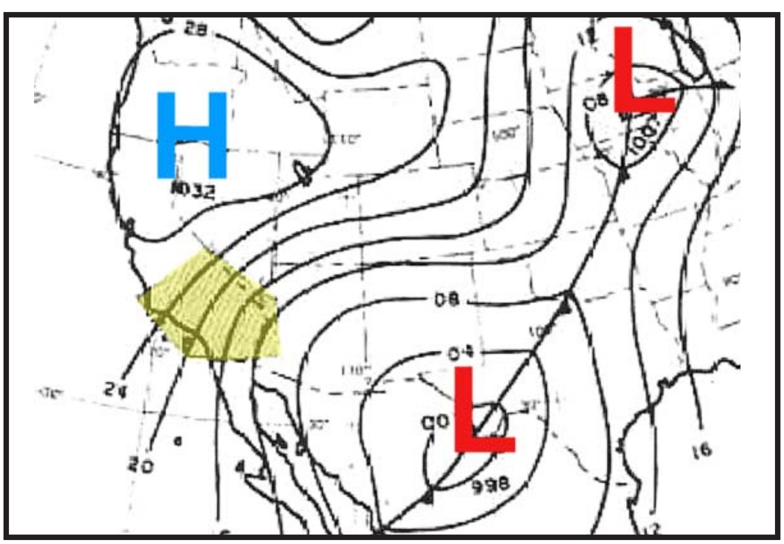

Figure 3-39. Los Angeles Box Surface Example 2.

States (presented in Chapter 2). A Santa Ana wind setup may occur when these deepening lows become closed as they drop southward into southern Utah and Arizona as shown in Figures 3-38 and 3-39. An upper level ridge/high extends across the northern regions of the western United States, and in conjunction with the southwestern upper low, a north to northeast wind flow extends into the upper troposphere over southern California and Arizona. At the surface, a 1035-mb high should be located over central Nevada. This is the basic synoptic regime for "Santa Ana" wind outbreaks. Figure 3-40 illustrates a mid-level synoptic pattern favorable for Santa Ana winds.

Figure 3-41 depicts the typical mechanism for development of a Santa Ana wind event. On the left side of the illustration, the strong winds traveling down the mountains would reach to the surface (**cold** Santa

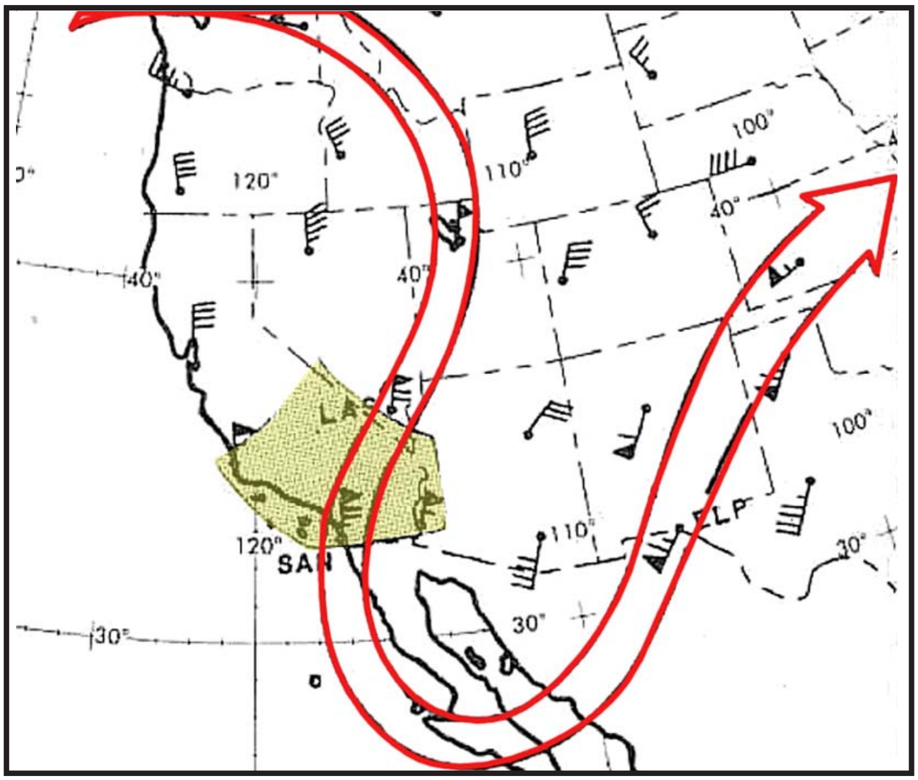

Figure 3-40. Los Angeles Box Mid-Level Maximum.

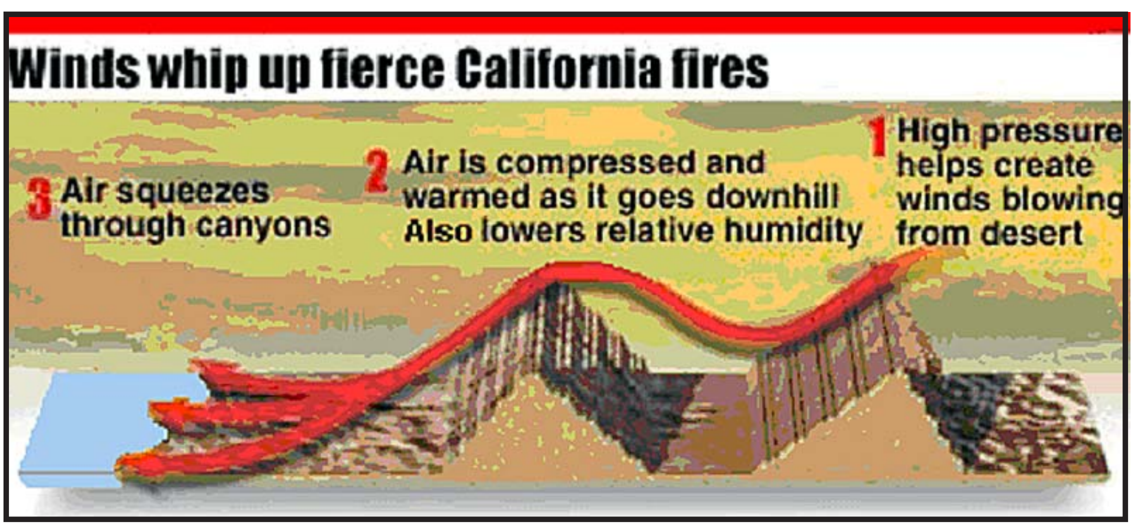

Figure 3-41. Santa Ana Vertical Wind Profile.

Ana). If a Pacific maritime polar (mP) ridge is in place over the ocean and adjoining land areas then most of the strong winds would ride over the mP inversion (**warm** Santa Ana) see Figure 3-45 below for further information on cold and warm Santa Ana wind events).

Figures 3-42 and 3-43 illustrate an excellent example of a Santa Ana wind event that produced disastrous fires over areas of Southern California. In the 500-mb chart (Figure 3-42), a strong northerly gradient lies over Nevada and the lower two-thirds of California with an upper low to the east.

At the surface (Figure 3-43), extensive anticyclones cover the entire United States (prevailing high). A 1036-mb high pressure system develops over the northern Rockies. The tighter pressure gradient across the southwestern United States is from an easterly to

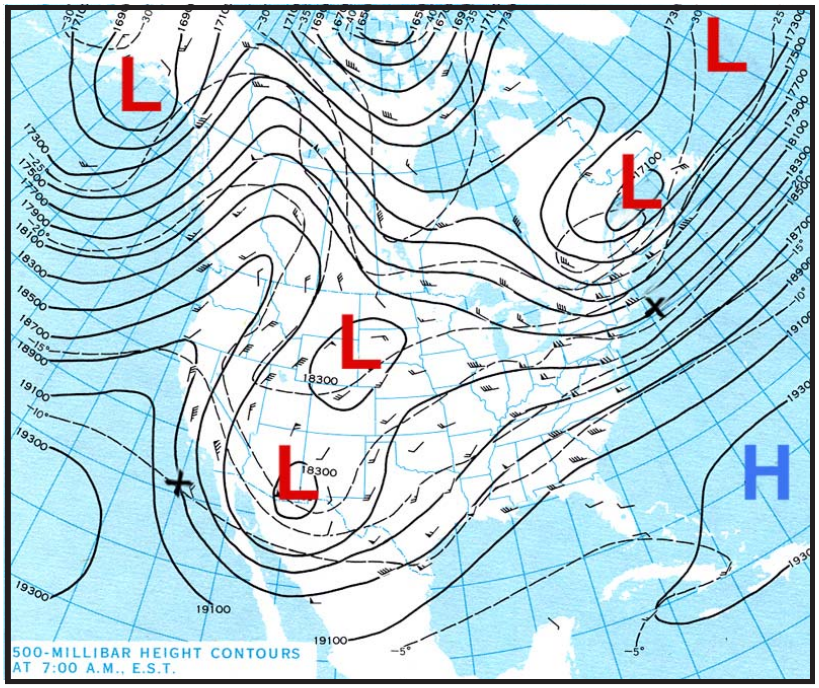

Figure 3-42. 500-mb Analysis, 1200Z/16 November 1980.

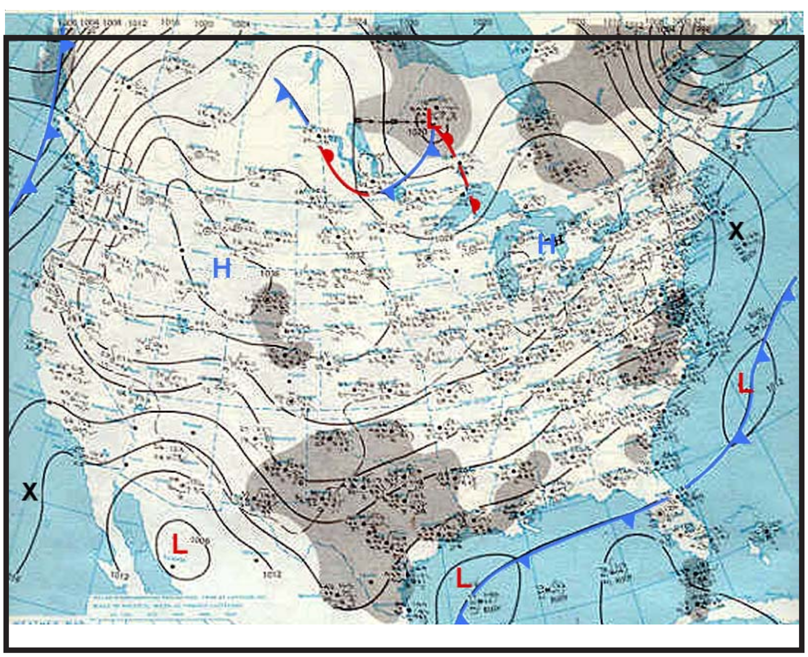

Figure 3-43. Surface Analysis, 1200Z/16 November 1980.

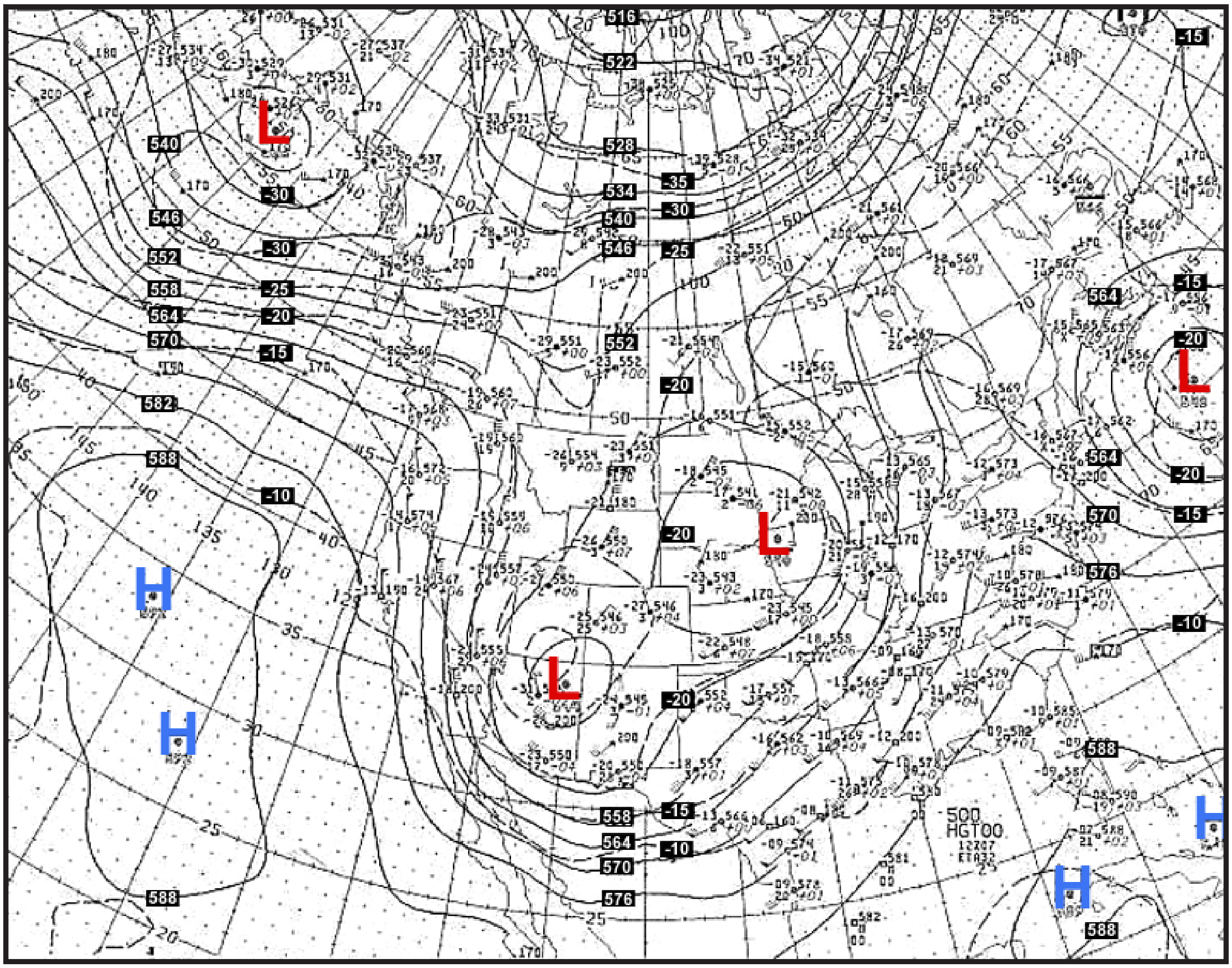

Figure 3-44. 500-mb Analysis, 1200Z/07 November 2000.

westerly component. This is the ideal component for desert winds to flow westward through the canyons and valleys to the coastal regions. Figure 3-44 depicts another 500 mb example, similar to the model shown in Figure 3-40.

Additional information on Santa Ana wind events is shown in Figure 3-45. Note that disastrous fires over southern California are often associated with Santa Ana conditions. Fires that develop over the parched brush lands of southern California, combined with a Santa Ana wind event, cause widespread destruction of land and hillside properties.

Santa Ana winds are foehn (or chinook)-like winds. The early settlers of Santa Ana, which is located southeast of Los Angeles and just east of the Santa Ana Mountains, named the Santa Ana winds. These winds occur primarily between October and February, with December being the most common month of occurrence. Summer events are extremely rare. With a Santa Ana event, stations typically have northeast to east winds. In addition, the San Joaquin Valley is likely to be fog-bound, and desert temperatures are unseasonably cold. The Santa Ana usually lasts one to two days and ends quickly as the Great Basin High weakens and moves on.

Stations normally see a rise in temperature and a fall in dew points prior to the onset of the Santa Ana. Primary onset time is 17-21Z with a secondary onset time of

09-11Z. Winds will normally subside between 00-02Z. Winds are especially strong below valleys and passes such as the Cajon Pass and Banning Pass. Wind velocities vary greatly over the Southern California region due to the funneling effect of these passes and valleys. Speeds commonly range from 25-60 knots, but speeds can reach 70 knots or more with stronger Santa Anas. The highest Santa Ana winds can reach 100 knots. Figures 3-46 and 3-47 show wildfires associated with Santa Ana winds.

Along the coast, the strongest winds occur most frequently during the night and early morning hours due to the absence of a sea breeze. The sea breeze occurs daily and can moderate the Santa Ana winds during the late morning through the afternoon hours.

Southern California Santa Ana – Things To Watch For

Moderate to strong Santa Ana winds:

- 1035-mb surface high located over central Nevada.
- Plus 10 mb pressures difference from southern Nevada to Los Angeles (KLAX).
- There are two types of Santa Ana winds:
  - **"Cold"** Santa Ana: Winds dig to the surface.
  - **"Warm"** Santa Ana: Winds less and spotty because they ride over a marine inversion.

Key surface stations to watch to alert forecasters for a Santa Ana onset:

- KNTD**:** Point Magu/Oxnard
  Lag Peak – AMOS site report attached to NTD observation.
  (Elevation of Lag Peak: 1200' MSL).

- **"Warm"** Santa Ana: Lag Peak Dry Bulb Temperature $\geq$65ºF.
  Dew Point $\leq$40ºF.
  Winds 020º- 070º at 30-60 knots

- **"Cold"** Santa Ana: Lag Peak Dry Bulb Temperature <60ºF
  Dew Point <35ºF
  Winds 020º- 070º at 50-90 knots or more.

For the best chance of >25 knot winds at KRIV/KSBD, you need Lag Peak wind directions to be from 040º- 080º. Strong winds expected at KRIV or KSDB if easterly winds are occurring at Lag Peak plus a **"cold"** Santa Ana.

Figure 3-45. Some Santa Ana Forecasting Rules. Courtesy of National Weather Service Forecasters from Los Angeles, CA (KLAX).

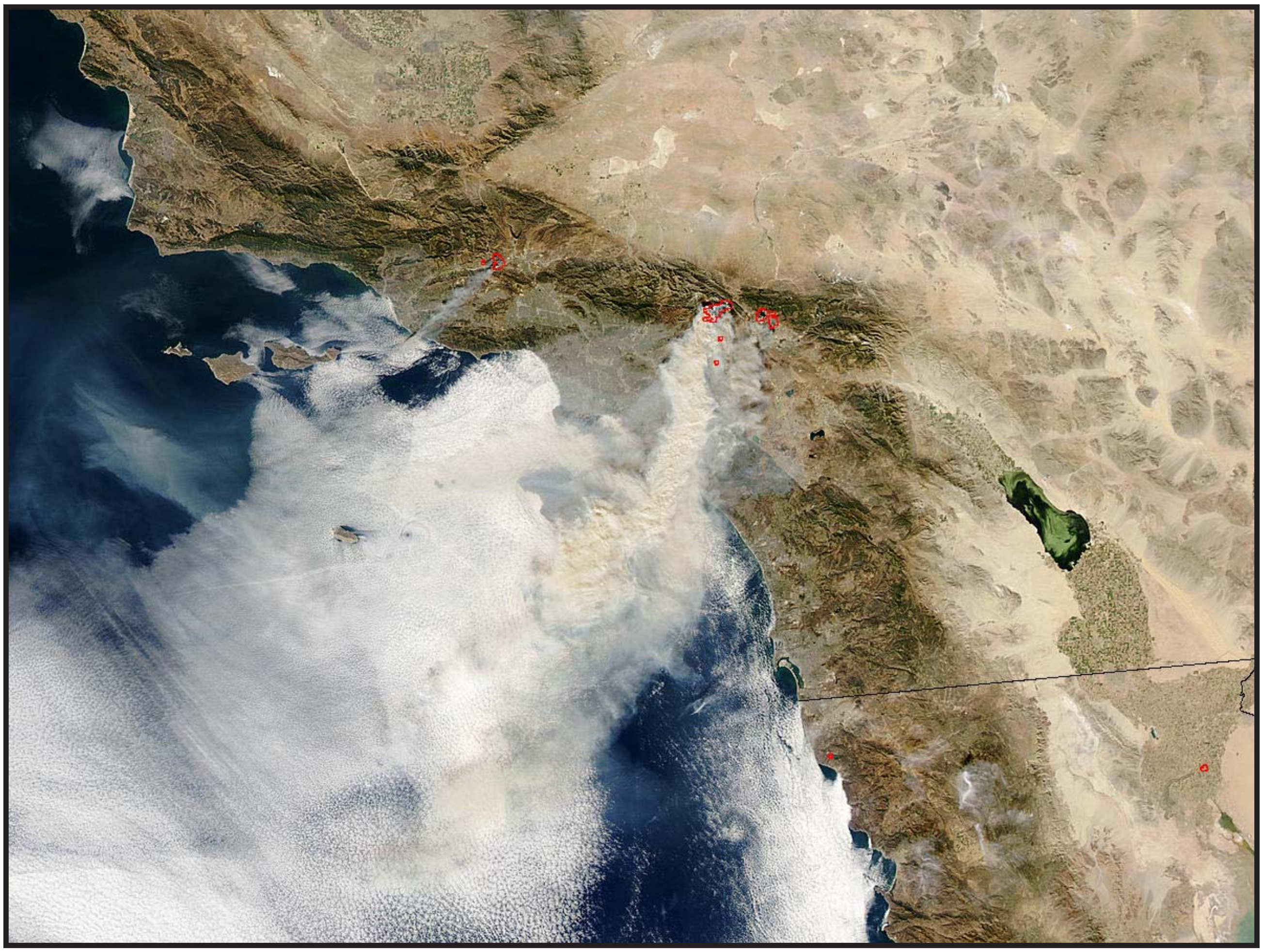

Figure 3-46. Southern California Wildfires Associated with Santa Ana Winds. This image of southern California and the city of Los Angeles (center) on October 25, 2003 shows a huge wildfire was burning east of the city (red outline). Just one day later (Figure 3-47), several massive fires were raging across the region, driven by the fierce Santa Ana winds that blow toward the coast from the interior deserts. Image courtesy MODIS Rapid Response Team at NASA.

Figure 3-47. Southern California Wildfires Associated with Santa Ana Winds. Whipped by the hot, dry Santa Ana winds that blow toward the coast from interior deserts, at least one fire grew 10,000 acres in just 6 hours. Image courtesy MODIS Rapid Response Team at NASA.

THUNDERSTORMS.

By late September, thunderstorm activity decreases significantly as the subtropical high shifts southward and destroys the south to north monsoonal flow prevalent during summer. Afternoon moderate or severe thunderstorms associated with the monsoon moisture are likely to continue mainly over the southwestern United States through the end of September (Figure 3-48).

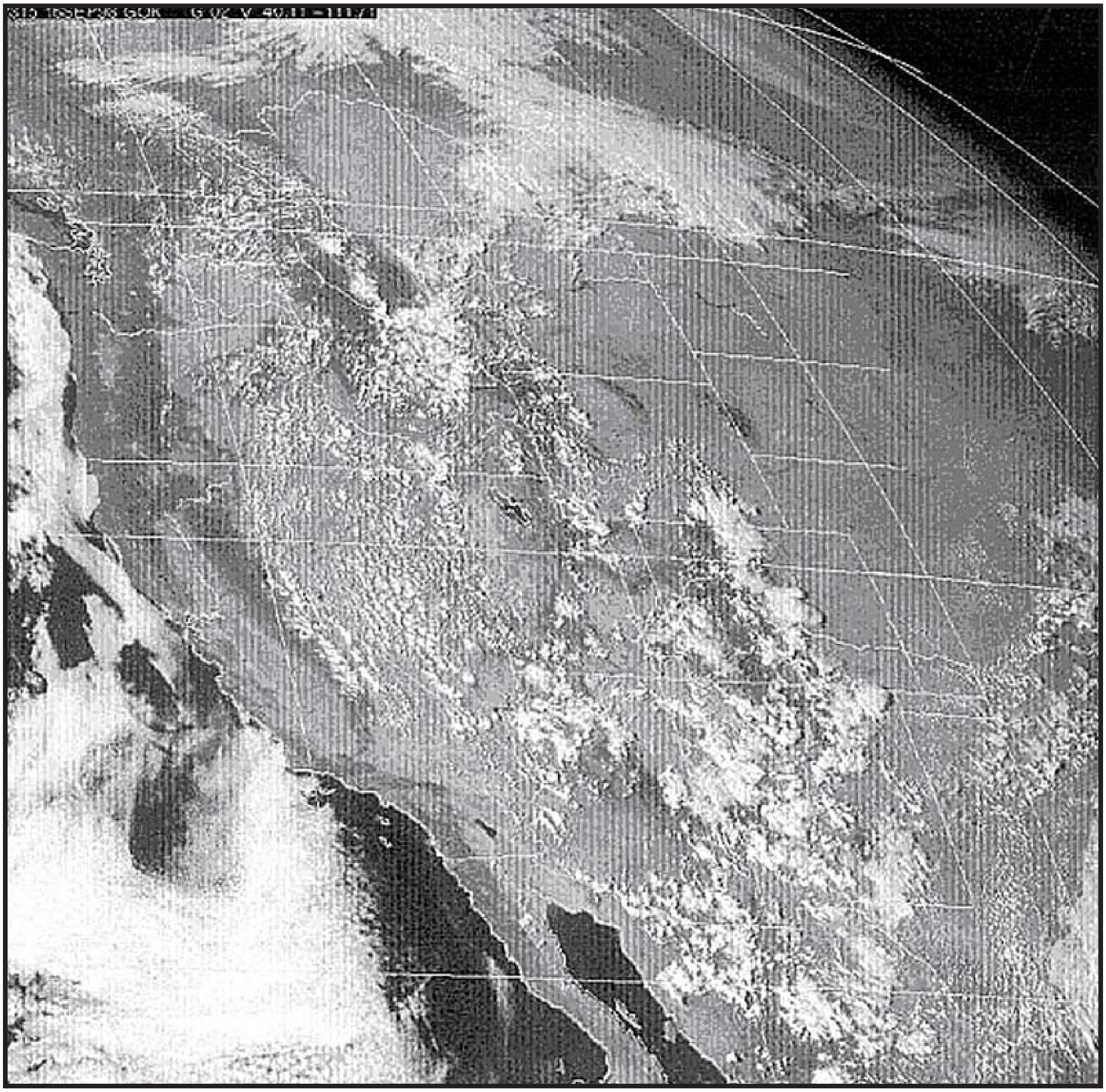

Figure 3-48. GOES West Visible, 2315Z/16 September 1998. This mid-September photo shows an active monsoon event.

By October, monsoon thunderstorm events across the region become rare. Most thunderstorm occurrences would likely be associated with frontal activity or upper level troughs/cold pockets as shown in Figure 3-49.

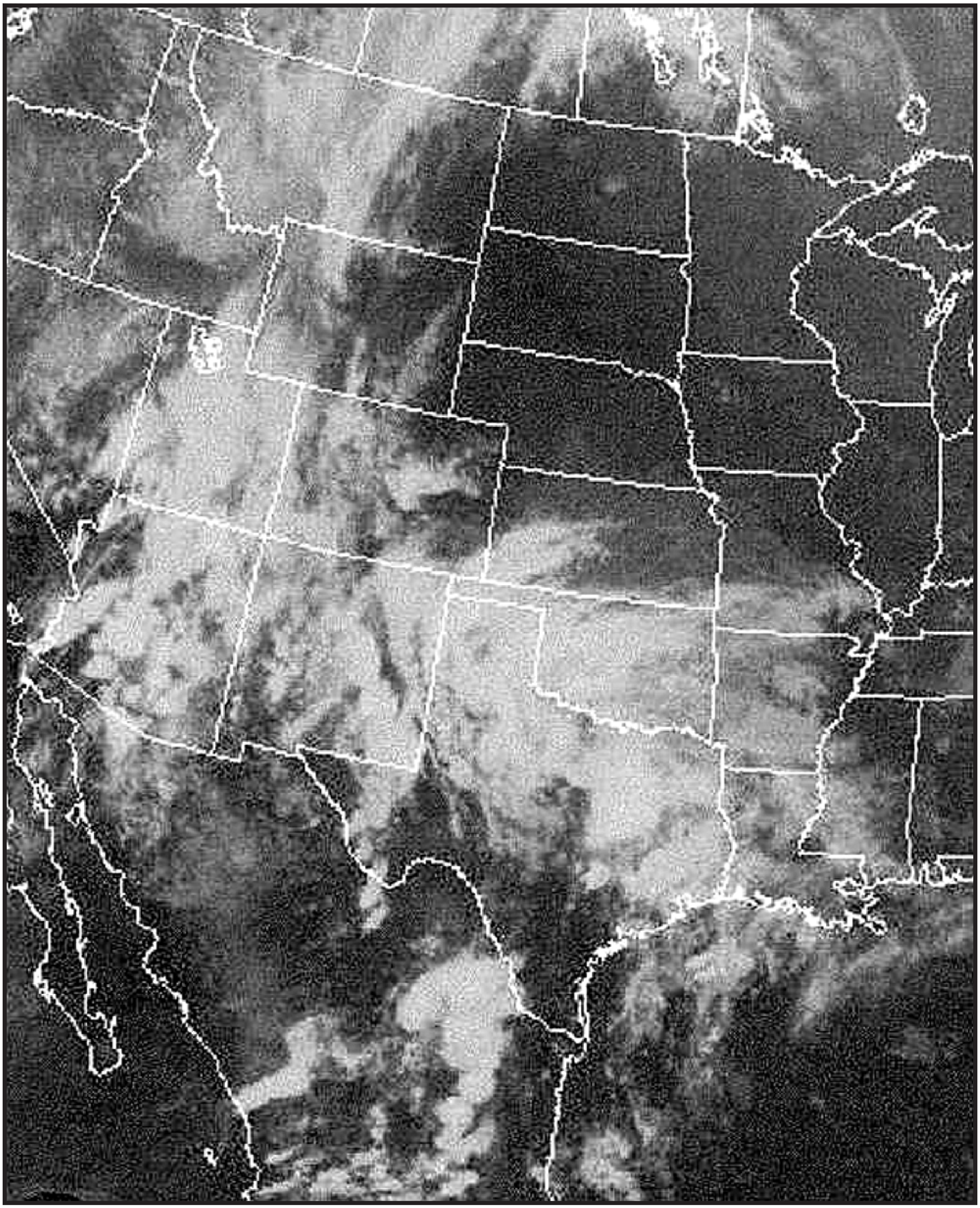

Figure 3-49. GOES West Infrared, 2245Z/21October 2000.

Chapter 4

CENTRAL UNITED STATES

STORM TRACKS/FRONTAL SYSTEMS (GENERAL).

Chapters 2 and 3 contained a discussion of synoptic regimes pertaining to short and long wave troughs and polar and subtropical jet stream systems. Short wave systems are often observed across the United States during autumn; long wave regimes begin by mid November.

At the onset of autumn, low-pressure systems still follow the summer regime and lie across Canada and the northern United States (Figure 4-1). The associated maritime polar (mP) cold fronts, however, penetrate deeper into the United States during early autumn as upper-level pressure, wind and temperature gradients become stronger. Additionally, the subtropical high and its weaker gradients shift southward. Intrusions of continental polar (cP) fronts become more frequent by mid October.

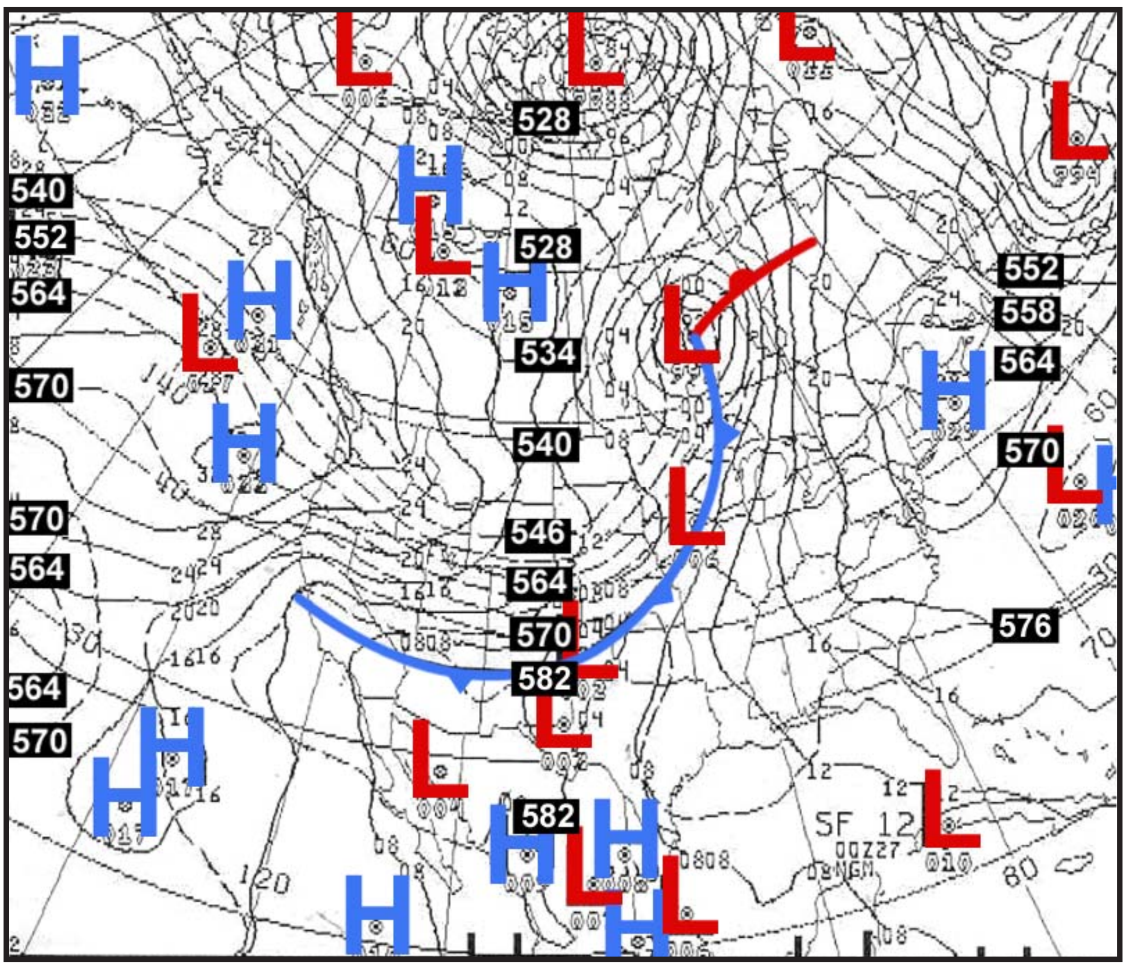

Figure 4-1. 12-Hour Forecast Mean Sea-Level Pressure/1000-500-mb Thickness, 0000Z/27 September 1999. Pacific maritime polar (mP) cold front forecast to move into the central Great Plains.

By November, low-pressure systems move southward across the northern United States (Figure 4-2). This southward shift of storm tracks from Canada leads to more cold air stratus and cumulus clouds within the northwest cyclonic flow across the upper Midwest and eastward (Figure 4-3). By late autumn and continuing into winter, cold low-level cloudiness progressively shifts further southward with each passing disturbance.

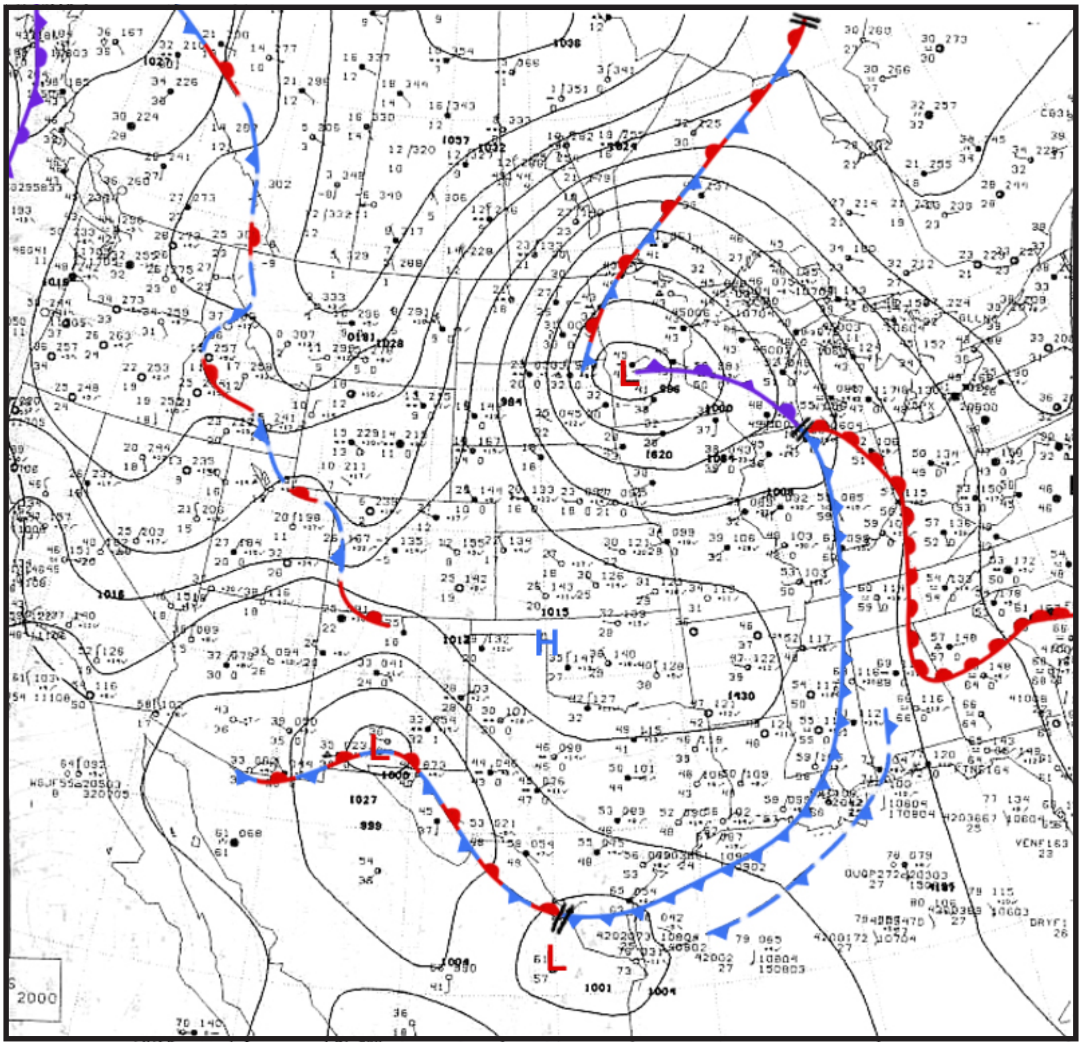

Figure 4-2. Surface Analysis, 1200Z/7 November 2000.

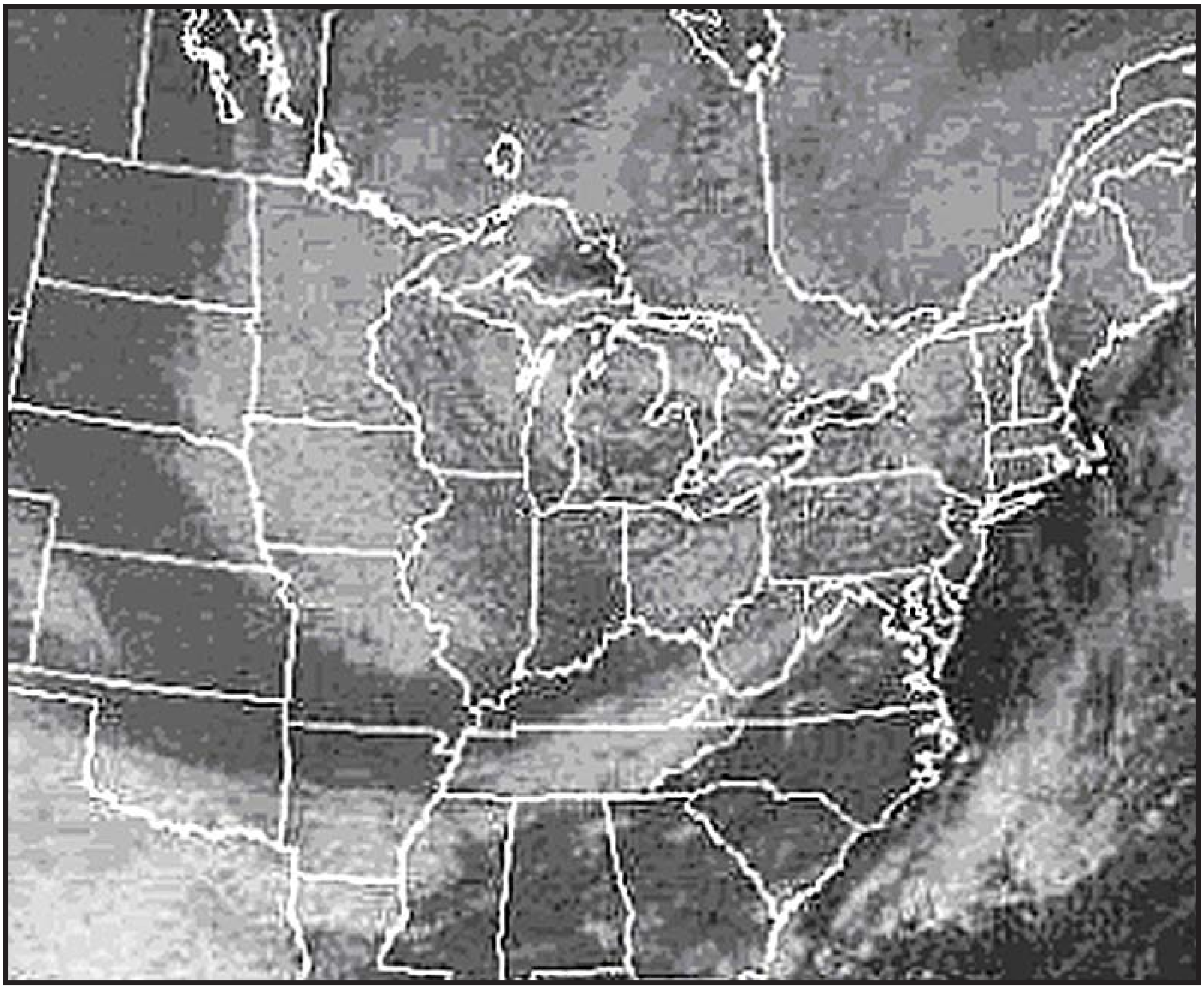

Figure 4-3. GOES-E Visible, 1845Z/7 October 2000. Extensive cold air stratus and cumulus within a cyclonic flow is seen over the upper Midwest.

Although measurable snowfall begins across the northern tier of states during October, intrusions of polar air masses from Canada into the United States may stagnate and develop into "warm" highs. This results in delightful autumn weather called "Indian Summer."

Generally, October's weather is pleasant during the quiet period as summer fades and before winter's onslaught begins in November. In the nighttime DMSP composite image shown in Figure 4-4, a tranquil atmosphere is noted across the central and eastern United States with very little cloudiness.

Figure 4-5 illustrates a quiet weather day across the nation. Cloudiness across Arizona and New Mexico is moisture that has advected northward in association with Tropical Storm Juliette (see Figures 3-17 and 3-18).

Figure 4-4. DMSP Composite, 0147Z/16 October 1998

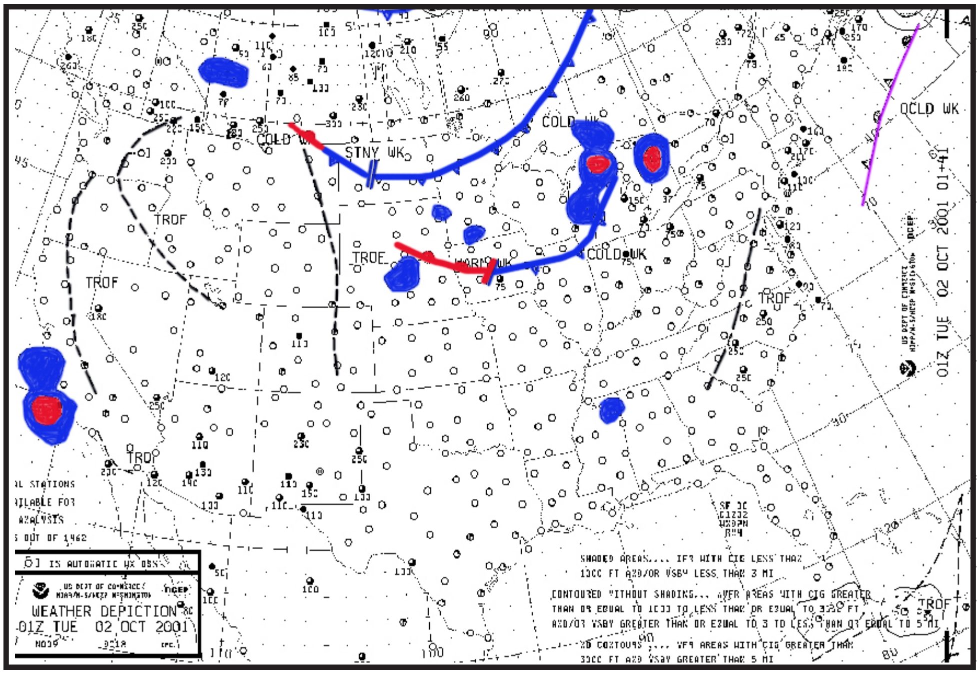

Figure 4-5. Weather Depiction, 0100Z/02 October 2001.

Conversely, October's weather regimes can be challenging with premature winter storm systems over the central and eastern United States (i.e. a rare significant freezing rain event occurred over the central Great Plains and heavy snowfall over the Dakotas in late October 1991). The following case study reveals how intense winter-like storm systems can develop quickly over the northern United States. In this event, heavy snowfall occurred over eastern North Dakota (over 10 inches in the Grand Forks area within the comma's deformation cloud system) and a severe frontal thunderstorm line swept across the central and southern United States. The following sequence of events includes severe thunderstorm discussions and illustrations (additional discussions on thunderstorm development will be presented later in the thunderstorm section). Some satellite interpretation will be discussed. In Figure 4-6, the polar jet is digging southeastward across the western United States. A short wave and an associated upper low are located over the northern Rocky Mountains.

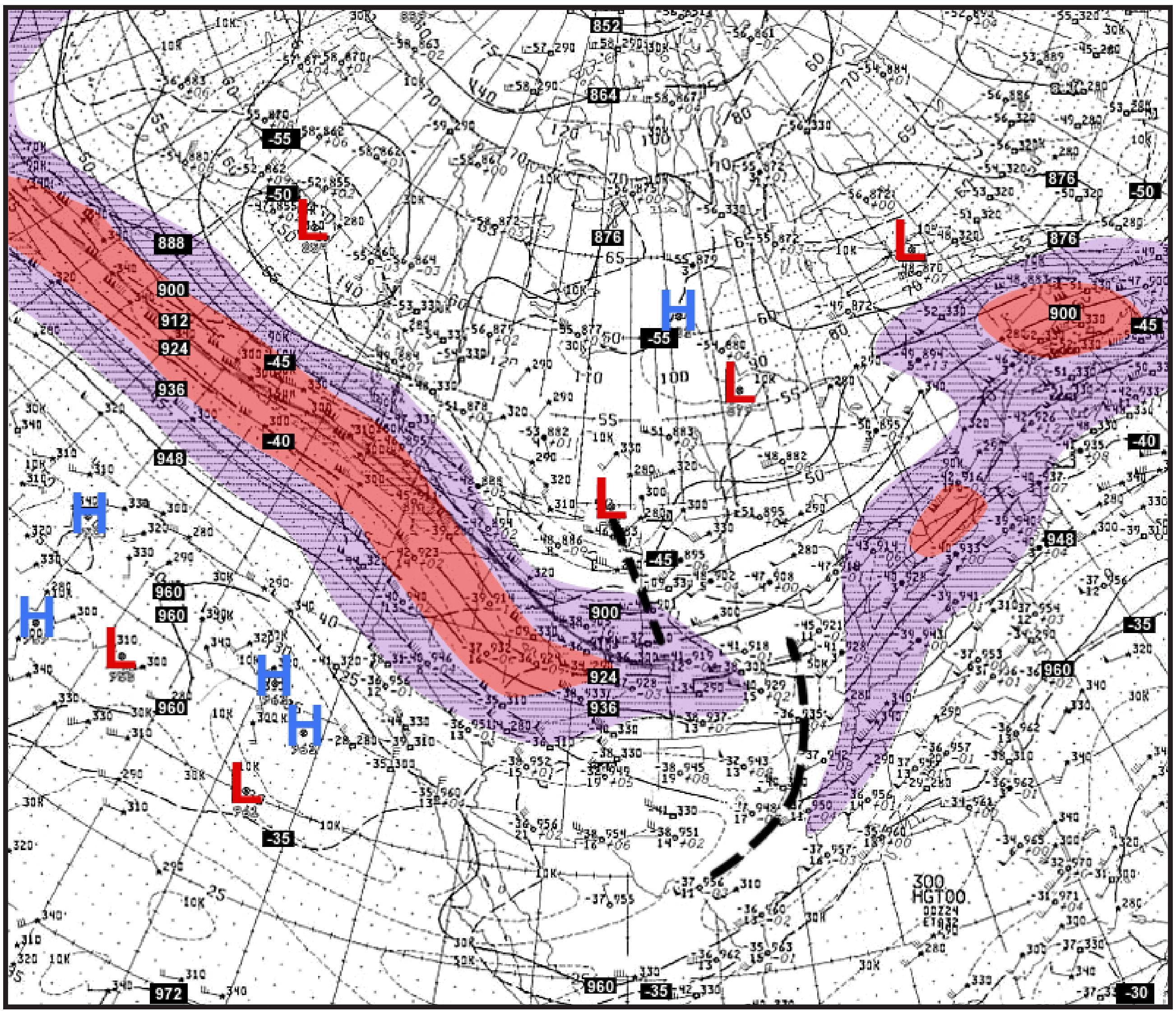

Figure 4-6. 300-mb Analysis, 0000Z 24 October 2001. Strong polar jet stream digging southeastward over the western United States.

Twelve hours later (Figure 4-7), the short wave trough's amplitude has sharpened over the central Great Plains, and a closed low has moved into North Dakota. Moderate to heavy snow will begin over northern North Dakota as the upper low moves eastward.

Figure 4-8 depicts the surface conditions nine hours after Figure 4-7. A deepening low and strong cold front appear over the central United States. Gulf moisture advected northward into Kansas and Missouri 48 hours earlier. The inset in Figure 4-8 shows extensive gulf moisture advection ahead of the cold front as noted by the cumulus streets.

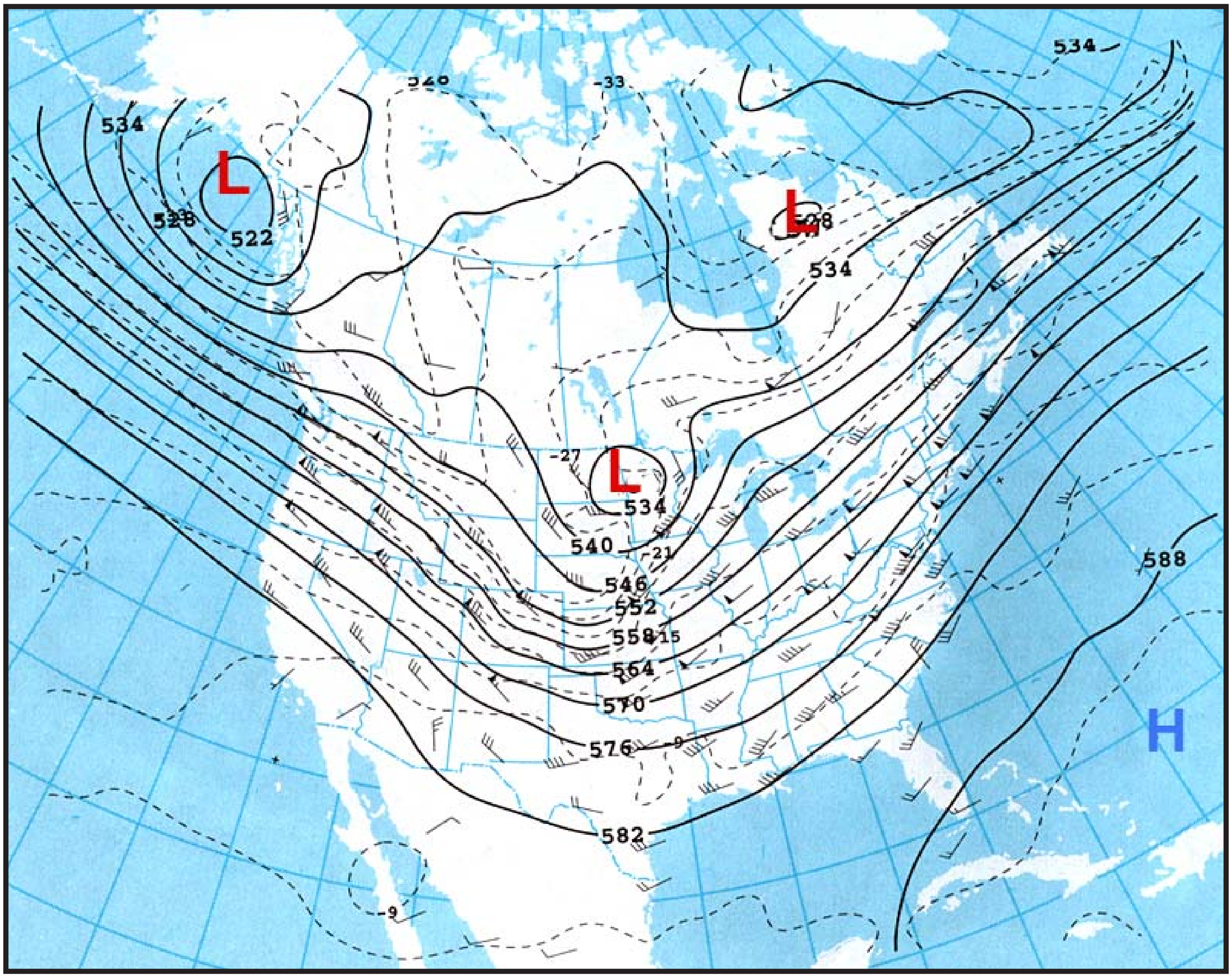

Figure 4-7. 500-mb Analysis, 1200Z/24 October 2001. Twelve hours later than Figure 4-6. Deepening short wave with a close low over North Dakota is shown.

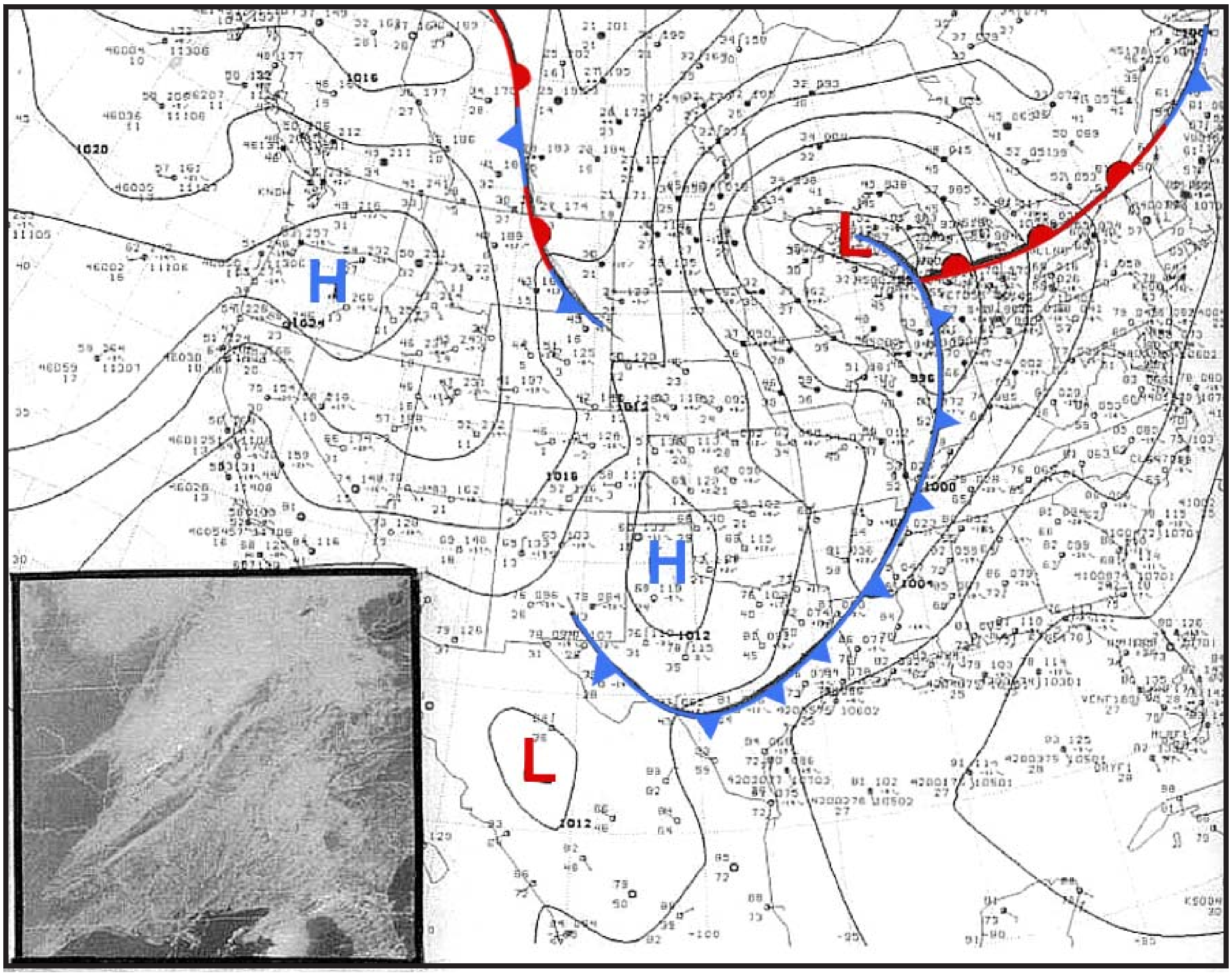

Figure 4-8. Surface Analysis, 2100Z/24 October 2001. Inset: GOES-E Visible, 1825Z/24 October 2001. Approximately two and one-half hours earlier.

The early afternoon visible image (Figure 4-9) reveals a strong comma system over the central United States. Positive vorticity advection has strengthened as shown in the inset in Figure 4-10 (four hours later from Figure 4-9).

A line of severe frontal thunderstorms has developed from the Great Lakes to Louisiana as illustrated in the radar summary chart, Figure 4-10. Strong PVA is occurring with this system as shown in the inset.

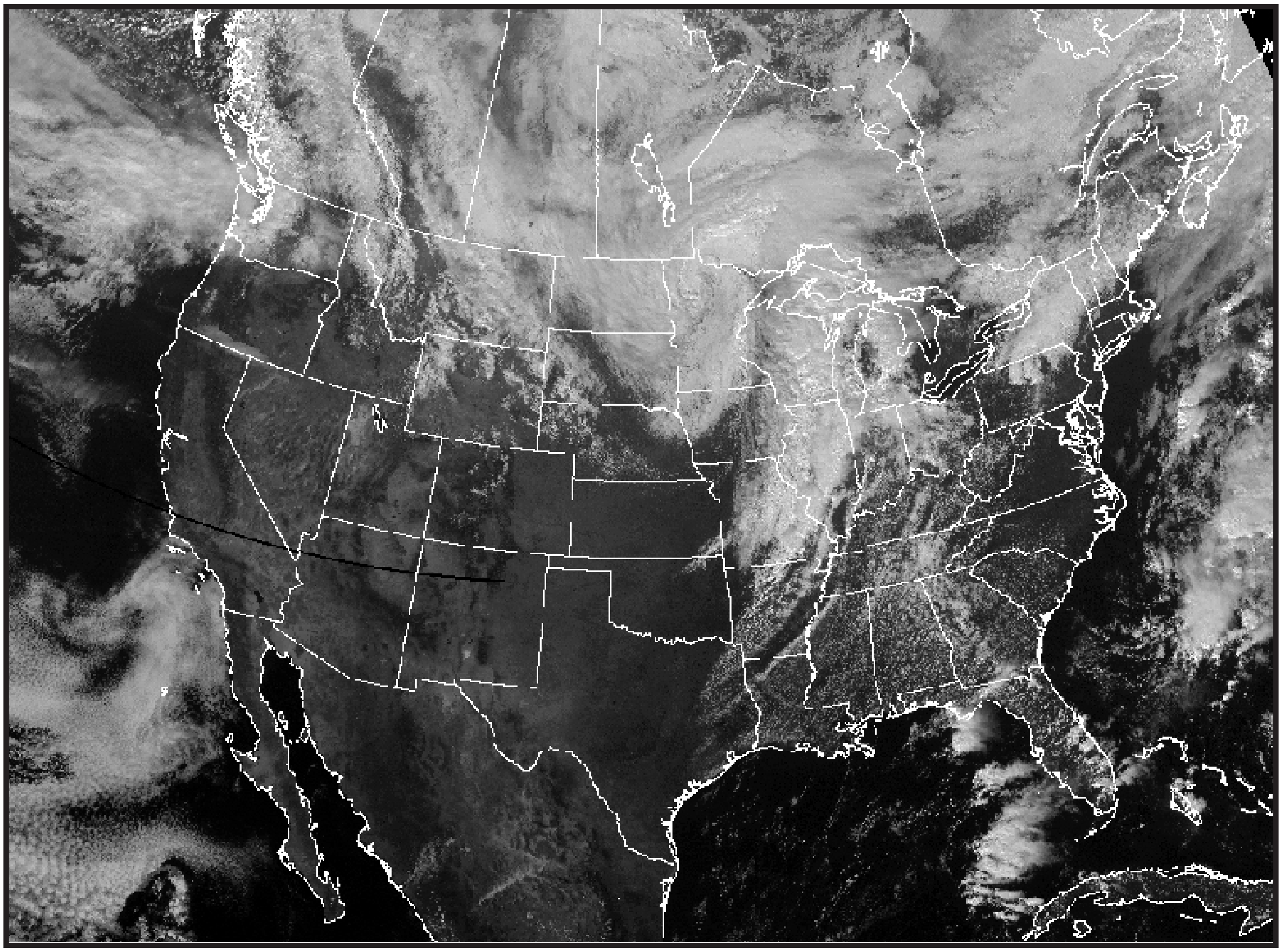

Figure 4-9. GOES-E Visible, 1910Z/24 October 2001. Developing comma cloud system appears over the northern United States.

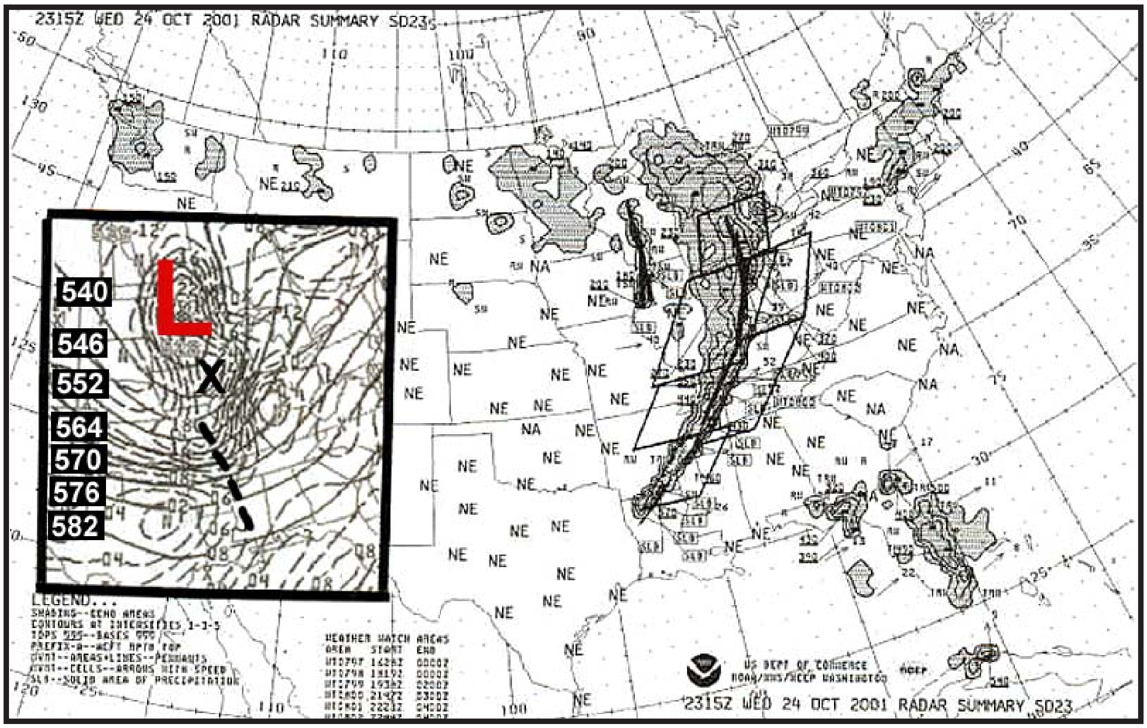

Figure 4-10. Radar Summary, 2315Z/24 October 2001. Inset: 12-Hour 500-mb Heights/ Vorticity, 0000Z/25 October 2001**.** In this late afternoon depiction, a nearly solid frontal thunderstorm line extends from Michigan to Louisiana. Severe thunderstorm watch areas are included.

Figure 4-11 illustrates an early evening segment of the 25 October 2001 severe thunderstorm line as it moved across western Ohio and northern Kentucky.

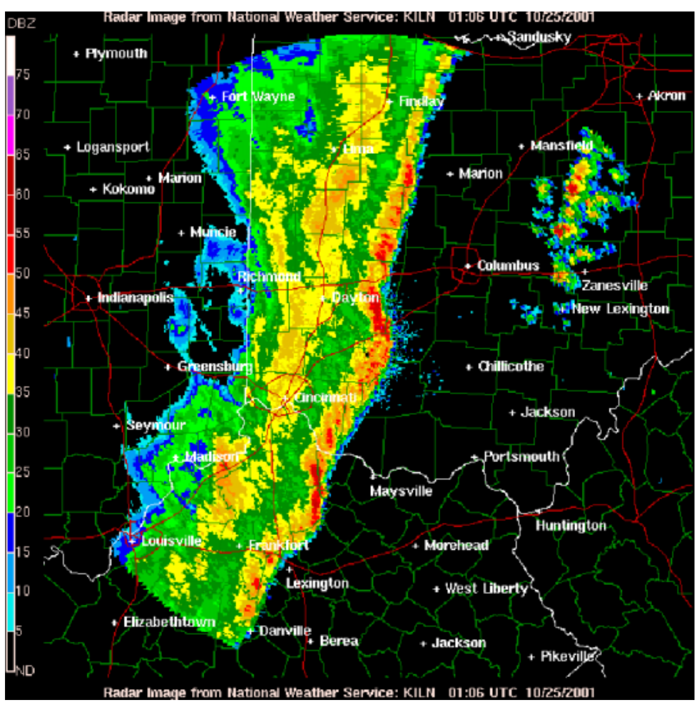

Figure 4-11. Radar Image Wilmington, OH (KILN), 0106Z/25 October 2001. Approximately two hours later than Figure 4-10.

Figure 4-12 depicts the surface conditions the following morning. Heavy snow is occurring over North Dakota and western Minnesota within the deformation cloud system of the comma. By this time, nearly all-frontal thunderstorm activity from New York southward along the front had dissipated overnight probably due to the loss of PVA, (and surface cooling) that lifted northeastward into northeastern United States and Canada as shown in the inset in Figure 4-13.

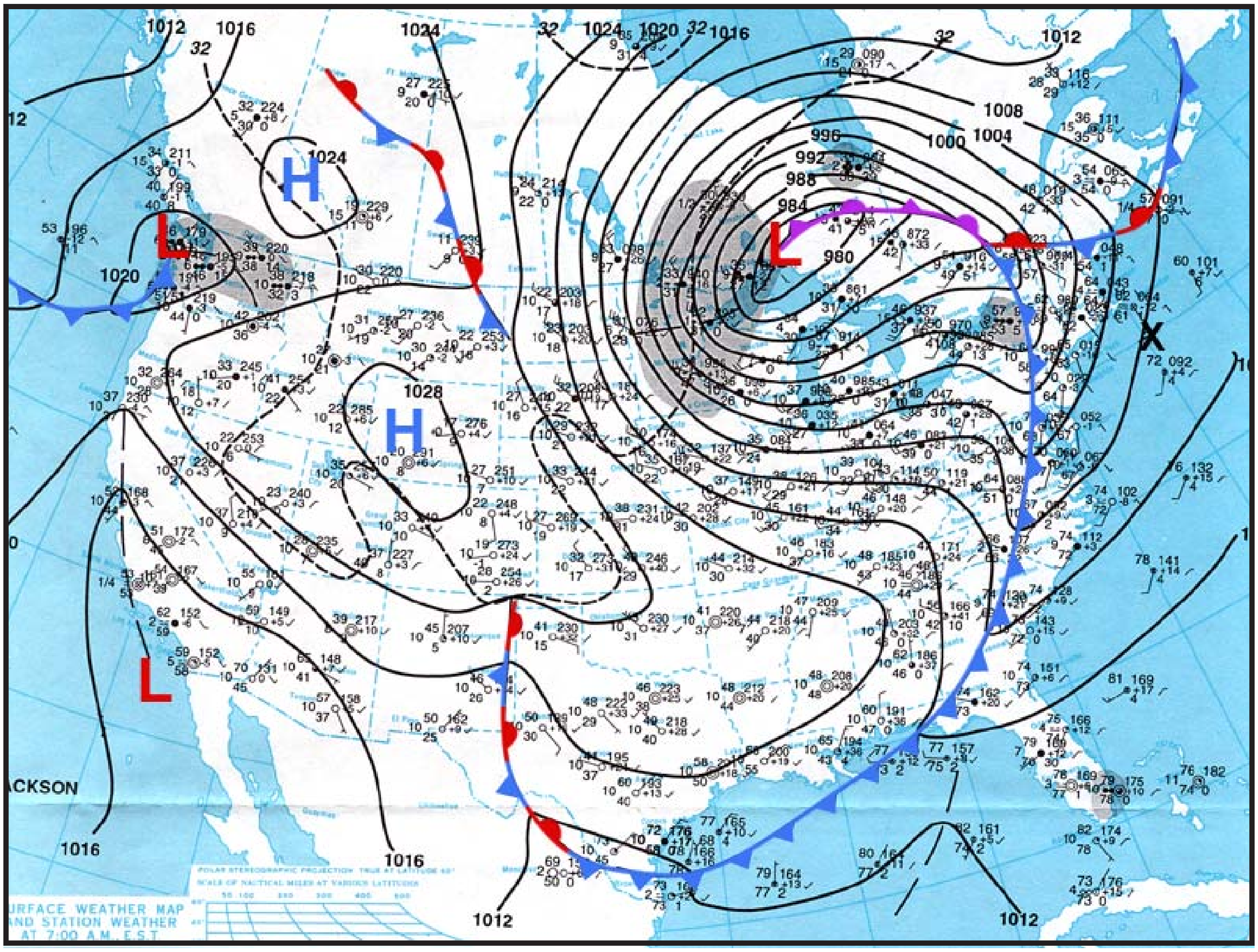

Figure 4-12. Surface Analysis, 1200Z/25 October 2001. Strong deepening continues as the low lifts northward into Canada.

Figure 4-13 shows the visible satellite image four hours later from Figure 4-12. By this time the cold frontal system had just moved off the east coast with the absence of thunderstorms. Thunderstorms shown off the Carolinas' coast and Florida have continued from the previous 24 hours. As shown in the visible satellite image in Figure 4-13, the baroclinic clouds associated with PVA ends sharply over the northeastern United States, which confirms the 12-hour ETA forecast of the PVA lobe (3 hours earlier from the satellite image; see yellow arrow). In the inset, the dashed line marks the axis between PVA and channeled vorticity west of the axis (dark arrow).

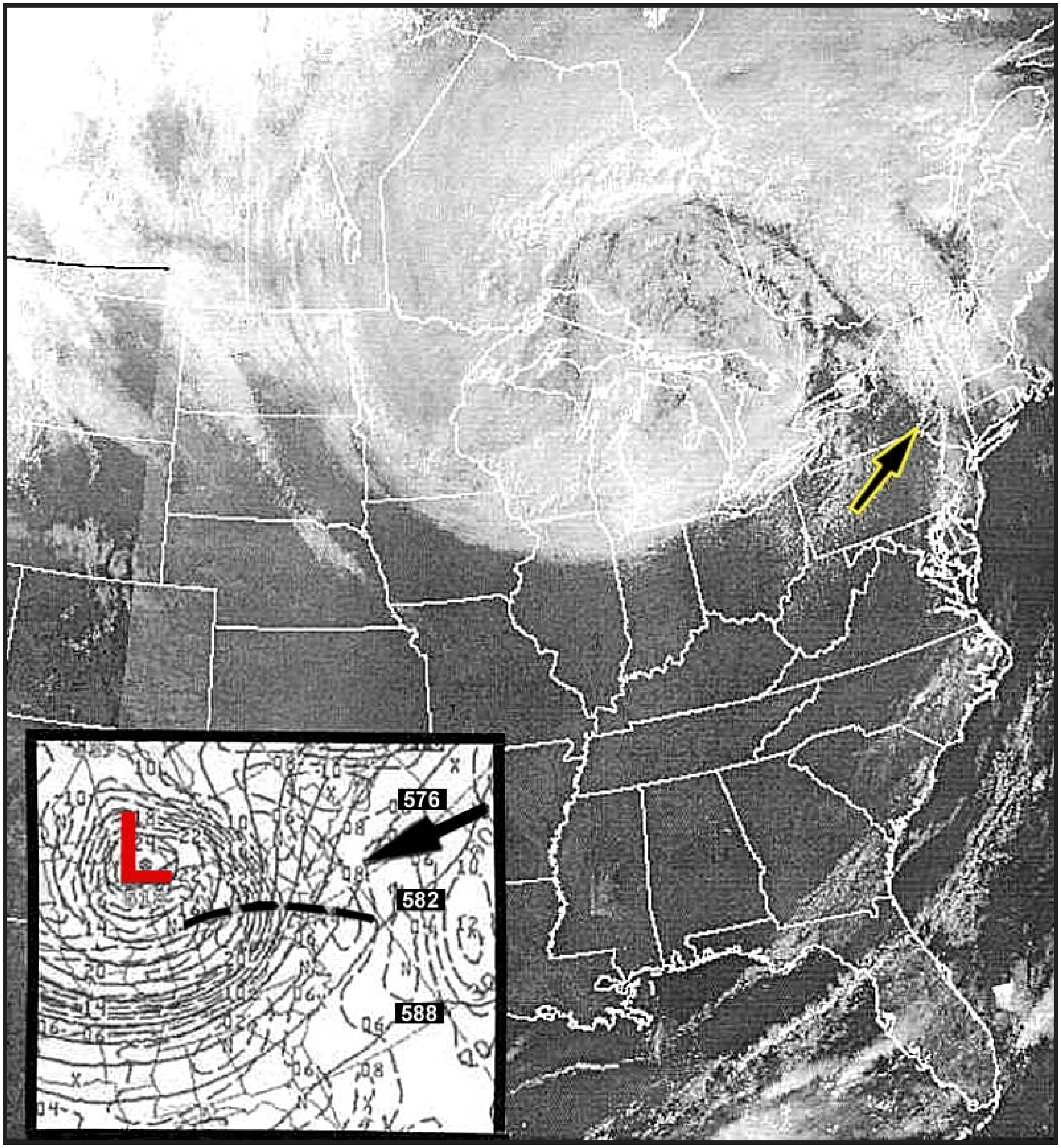

Figure 4-13. GOES-E/GOES-W Composite, 1630Z/25 October 2001. Inset: 12-Hour Forecast 500-mb Heights/Vorticity, 1200Z/25 October 2001 (Over 24 hours earlier than the satellite image).

Severe thunderstorm reports associated with this October 24 system are shown in the final illustration, Figure 4-14. As can be seen from this case study, October can produced significant severe thunderstorm events although the frequency of occurrence does not match more frequent severe events during the warm season.

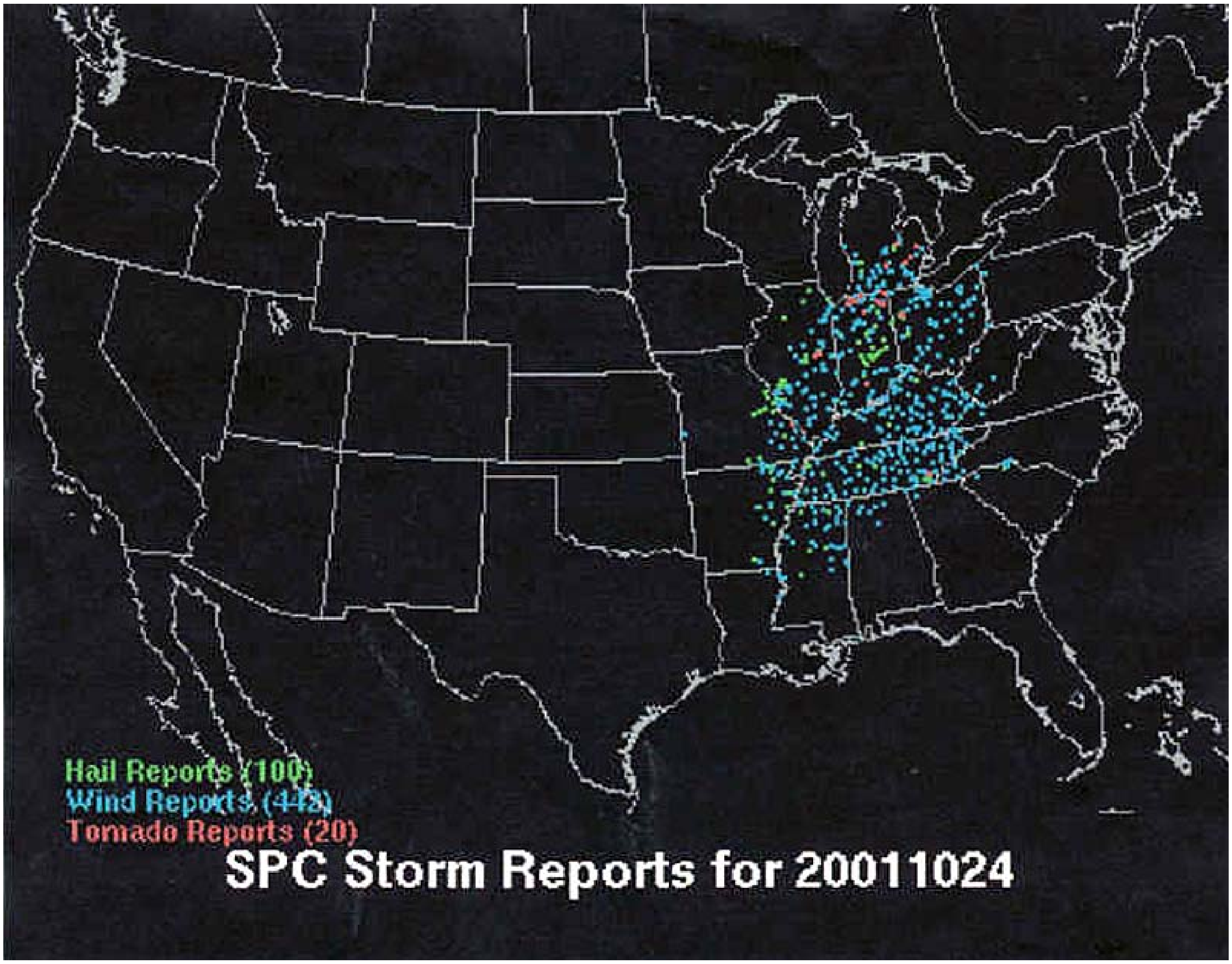

Figure 4-14. Storm Prediction Center Severe Reports, 24 October 2001..

STORM TRACKS/SHORT WAVE SYSTEMS.

In this section, tracks of storms associated with short waves regimes will be shown. A case study review is presented in Figures 4-15 through 4-20 that illustrates the movement of a typical short wave across the United States which may produce a significant storm. In Figure 4-15, a short wave is shown over the western United States. The contour gradient has widened over the Great Basin region, which **may suggest** that an upper low is developing within the trough. In Figure 4-15, the yellow box indicates a favorable area for cyclogenesis. (**Note**: Cyclogenesis development (within upper troughs) that uses the wide spacing of contours concept on upper air analyses is presented in detail in Winter Regimes).

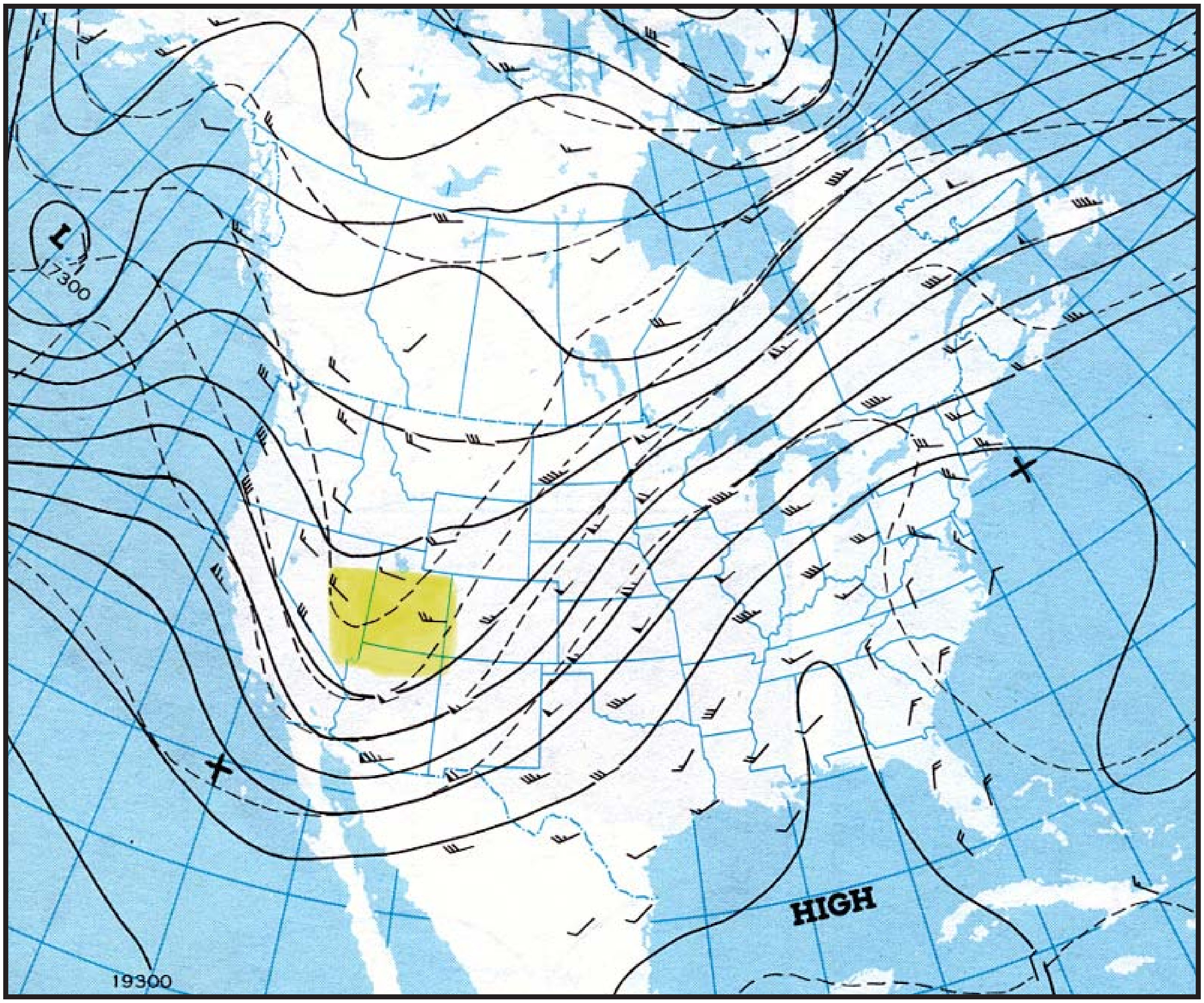

Figure 4-15. 500-mb Analysis, 1200Z/21 October 1979.

The related surface analysis, Figure 4-16, depicts an mP cold front from the Hudson Bay area, and extends southwestward across the central and southwestern United States. A cP frontal system is shown over the northern Great Plains and Rocky Mountains. A ridge from an Atlantic high covers the eastern and southern United States; advection of gulf moisture is likely within the southerly flow across Texas and the lower Mississippi Valley. Ingredients for development of a Great Plains storm look favorable: approaching upper trough, gulf moisture advection, frontal convergence and a cP airmass in place over the northern plains. In this example, pay attention to the frontal low over southwest Kansas. This low will be the primary low for development when the upper low approaches the western Great Plains (see Figures 4-17 and 4-18).

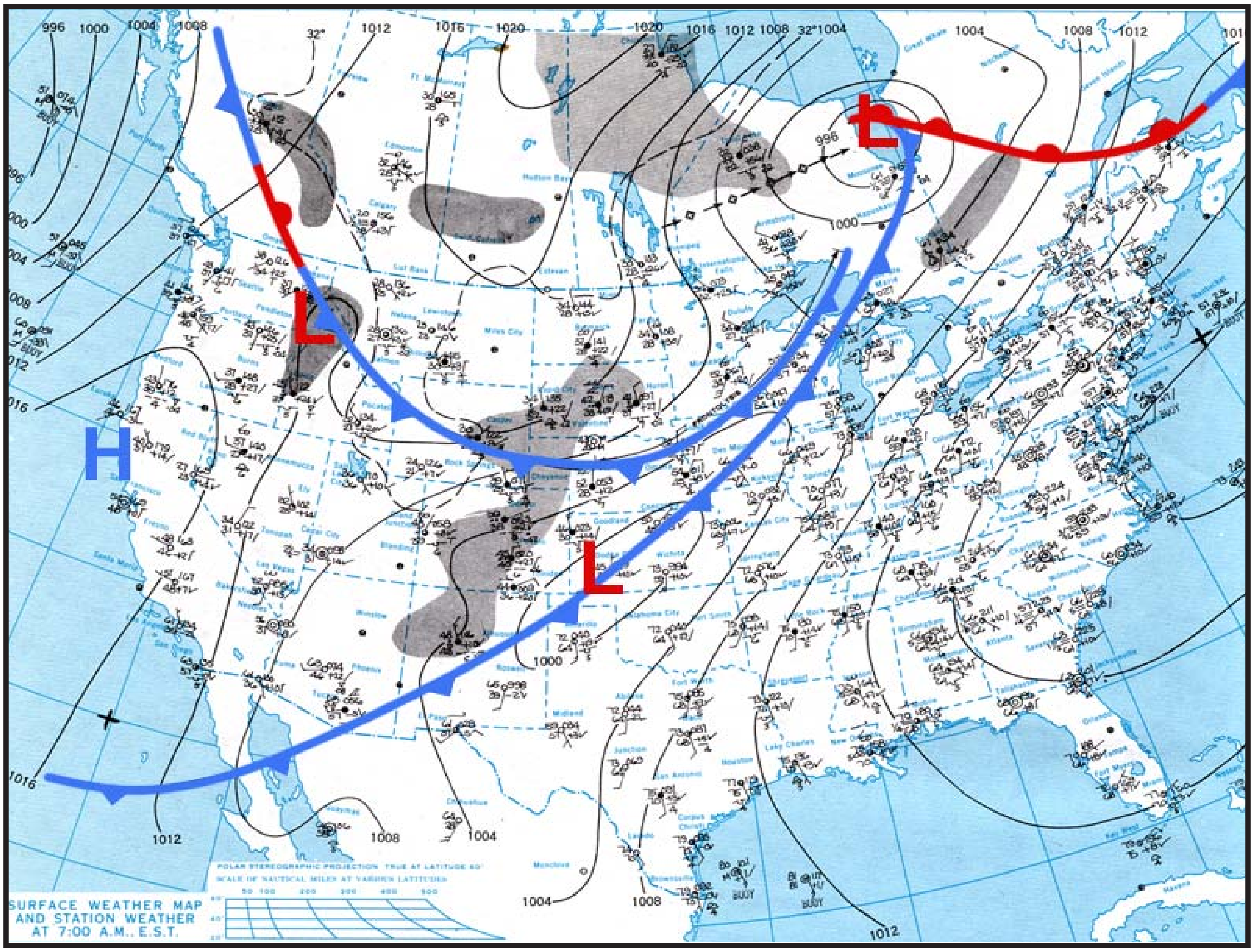

Figure 4-16. Surface Analysis, 1200Z/21 October 1979.

In Figures 4-17 and 4-18, twenty-fours later, a significant storm has developed over the Great Plains. In Figure 4-17, a low has formed within the 500-mb trough over the central plains. With strong ridging over the eastern United States, the developing disturbance would likely move northeastward. Precipitation shown over the Rocky Mountain region (shaded area in Figure 4-16) is associated with the approaching upper trough.

A significant change in the synoptic pattern occurred over the central United States during the next 24-hour period and is shown in Figures 4-17 and 4-18. In the 500-mb analysis, Figure 4-17, an upper low did form as the trough moved out of the Rockies. In response to deepening of the upper trough, the Kansas low shown in Figure 4-16 intensified over night and moved northeastward into Missouri (Figure 4-18). The cP airmass also shown in Figure 4-16 moved rapidly southward into the southern Plains and provided the cold air for continued storm intensification. Precipitation had increased significantly associated with increasing PVA and gulf moisture.

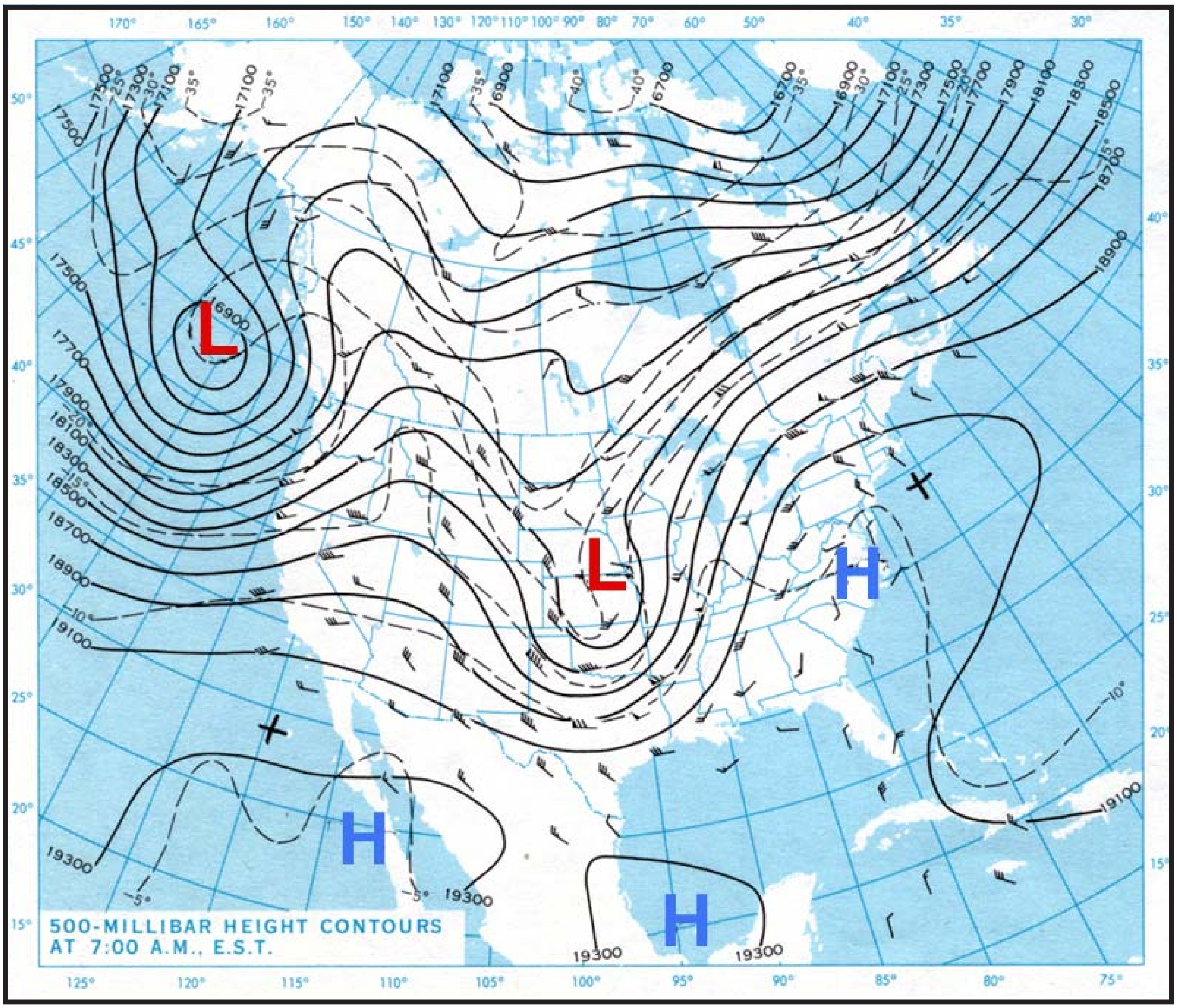

Figure 4-17. 500-mb Analysis, 1200Z/22 October 1979.

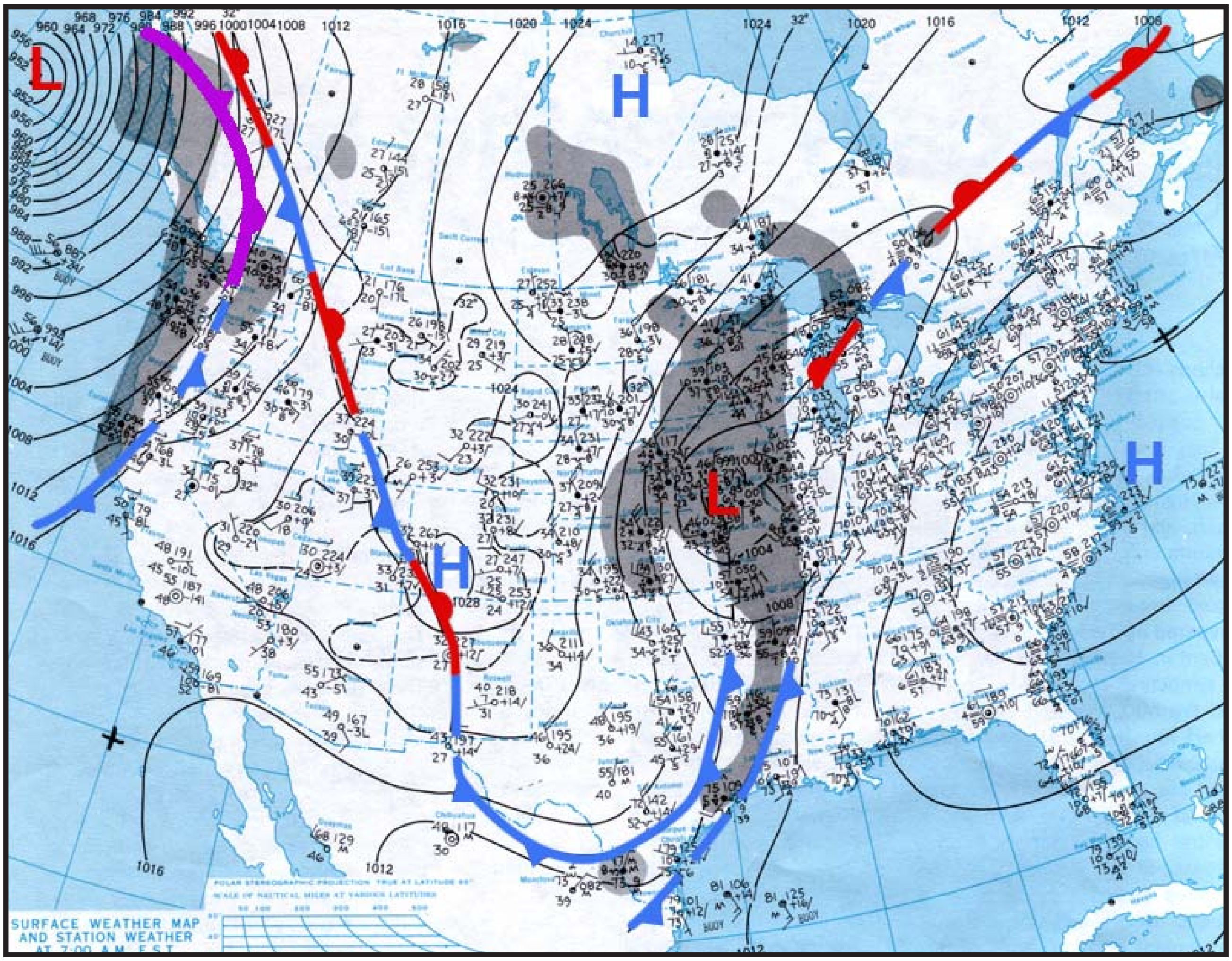

Figure 4-18. Surface Analysis, 1200Z/22 October 1979.

The final two illustrations, Figures 4-19 and Figure 4-20 (24 hours later), show a strong storm over the Great Lakes area. This case was a simple review of basic fall forecasting technique. The fall scenario requires that the reader adjust to more rapidly changing weather patterns than previously presented by the summer regime.

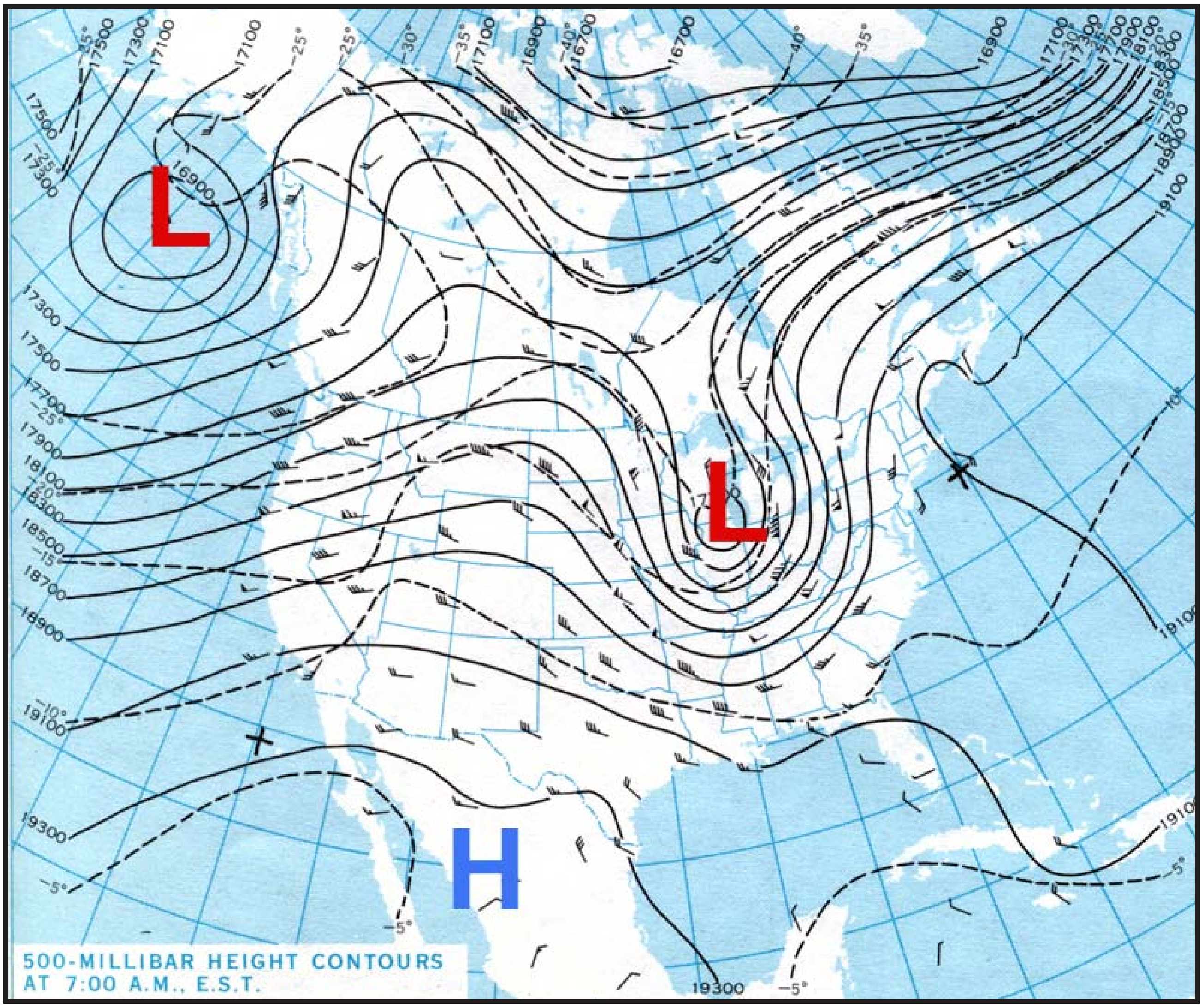

Figure 4-19. Surface Analysis, 1200Z/23 October 1979.

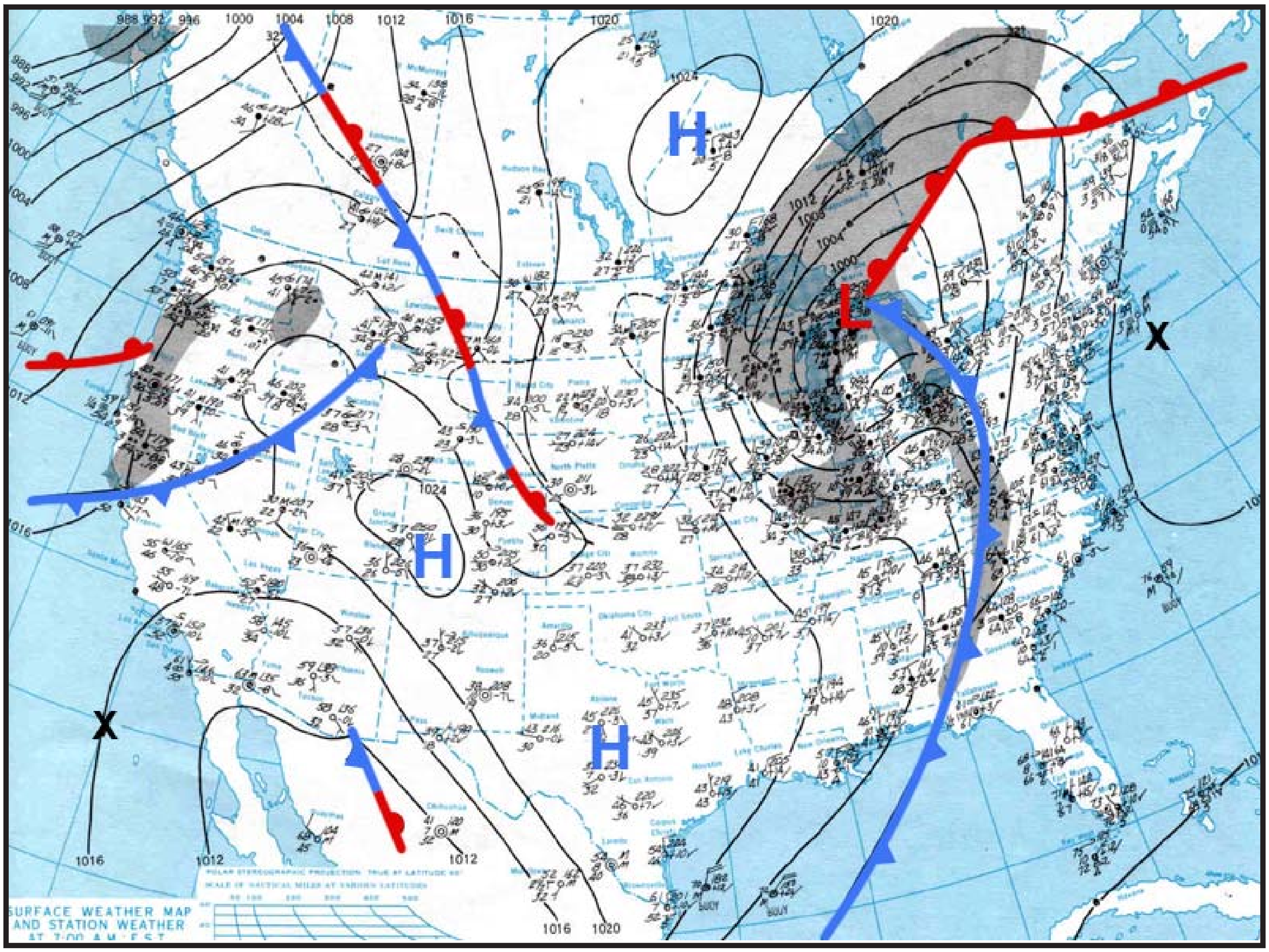

Figure 4-20. Surface Analysis, 1200Z/23 October 1979.

Storm Tracks – Alberta Cyclogenesis

Cyclogenesis within the lee-side trough east of the southern Canadian and/or northern Montana Rocky Mountains begins in November. Often a stationary polar front (oriented northwest to southeast) lies within the lee-side trough. Cyclogenesis is generally noted over the Alberta area when a southeasterly moving pacific short wave approaches the front. Figure 4-21 depicts typical Alberta low formation area. Strong surface winds over the northern Rockies and Great Plains often accompany Alberta Lows. If snowfall occurs, it will likely lie across the northern plains states along and north of the warm front (more detailed information regarding Alberta lows is presented in *Winter Regimes*).

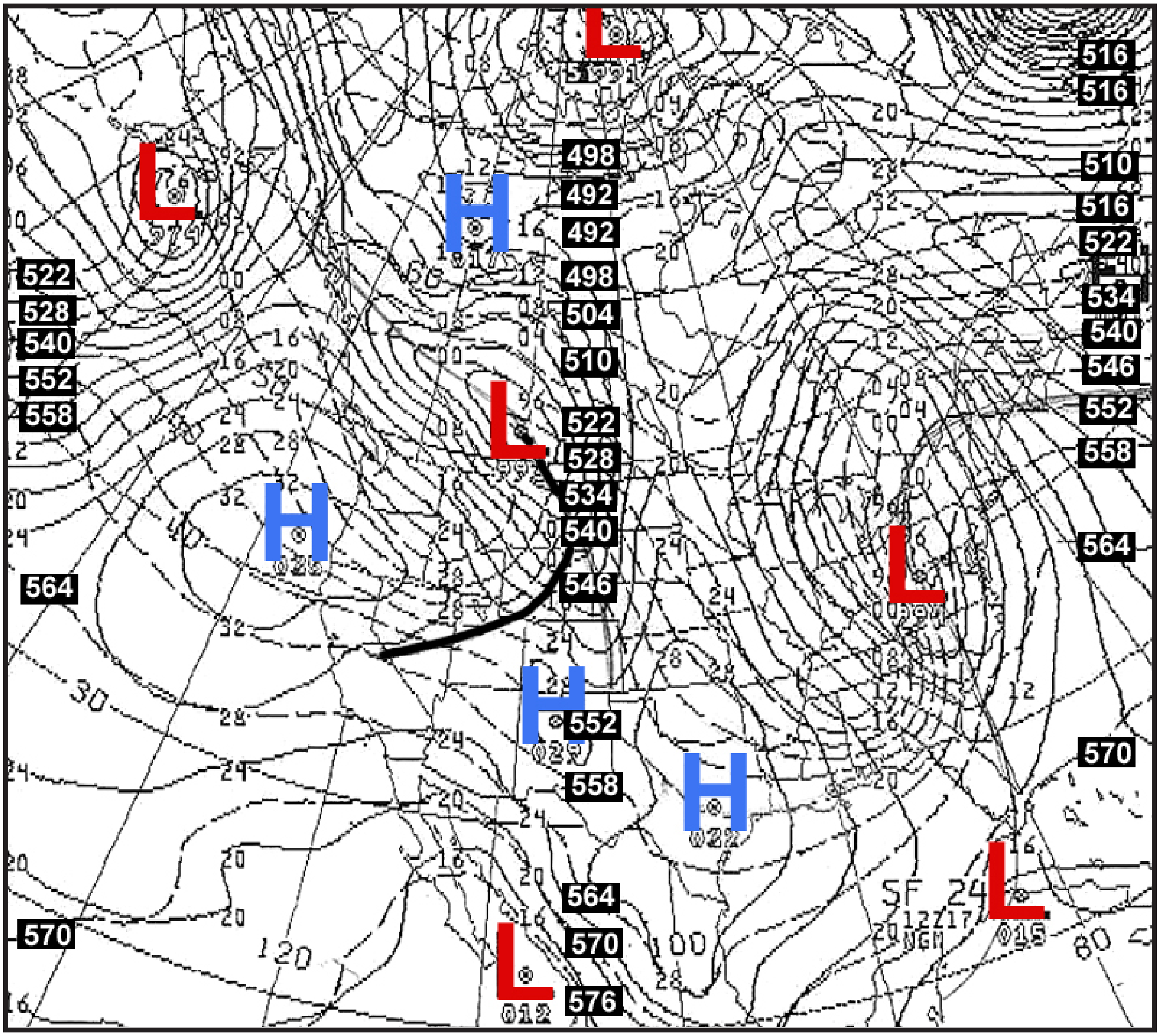

Figure 4-21. 24-Hour Mean Sea-Level/1000- to 500-mb Thickness, 1200Z/17 December 2000

Storm Tracks -Rocky Mountain Cyclogenesis

Significant storm development along the east slopes of the Rocky Mountains that may produce significant snowfall over areas of the Rockies and the western Great Plains are likely beginning by late October or early November. Surface lows appear frequently within the lee-side trough, mainly over eastern Colorado, during the year. During autumn and continuing through spring, however, forecasters should pay attention to these lee-side lows. These lows become dynamic (primary low) when the upper trough system approaches as shown by the 500-mb low over Colorado in Figure 4-22.

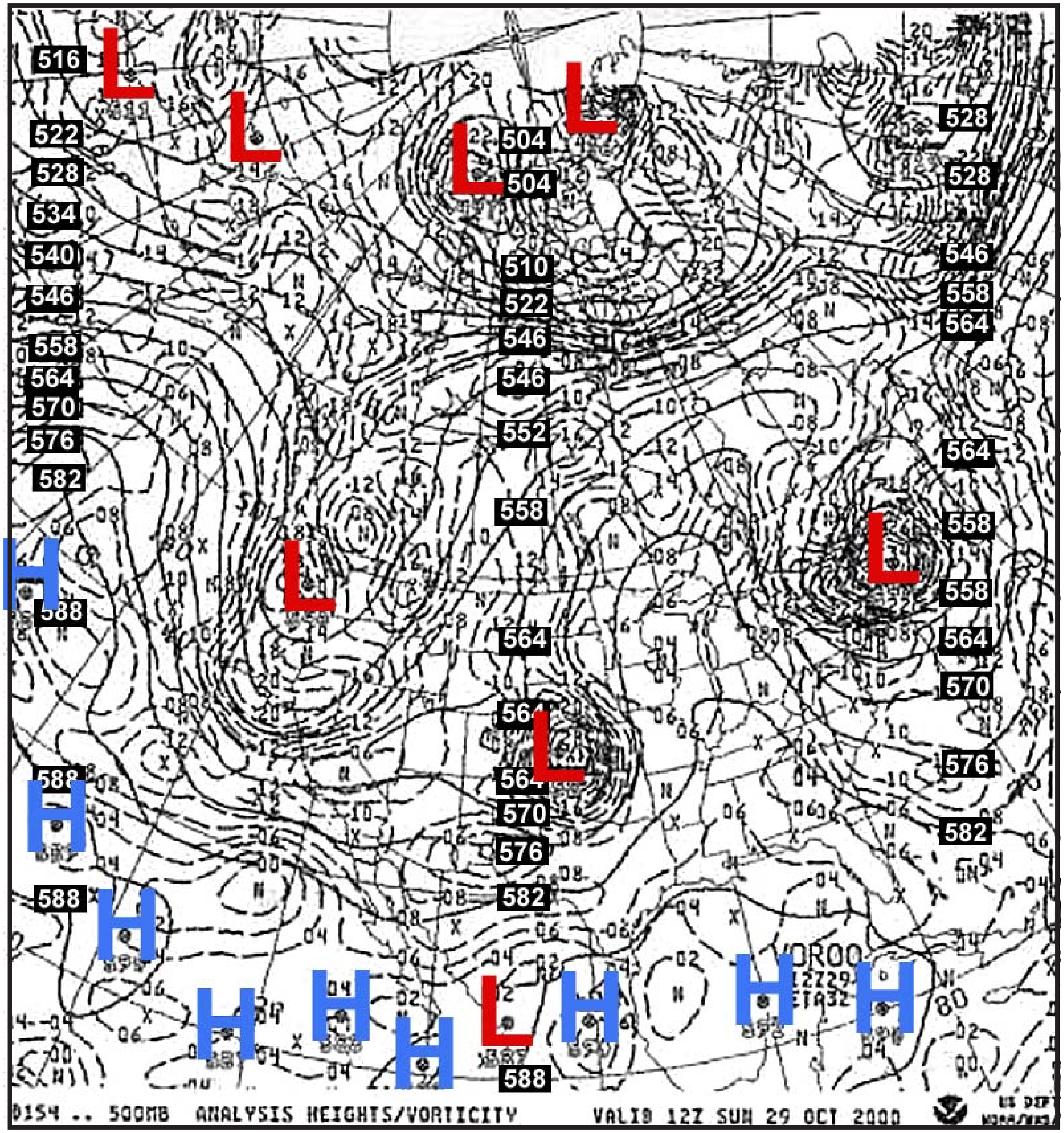

Figure 4-22. 00-Hour, 500-mb Heights/Vorticity, 1200Z/29 October 2000.

Figures 4-23 and 4-24 depict another example of cyclogenesis that occurred in the Rocky Mountains.

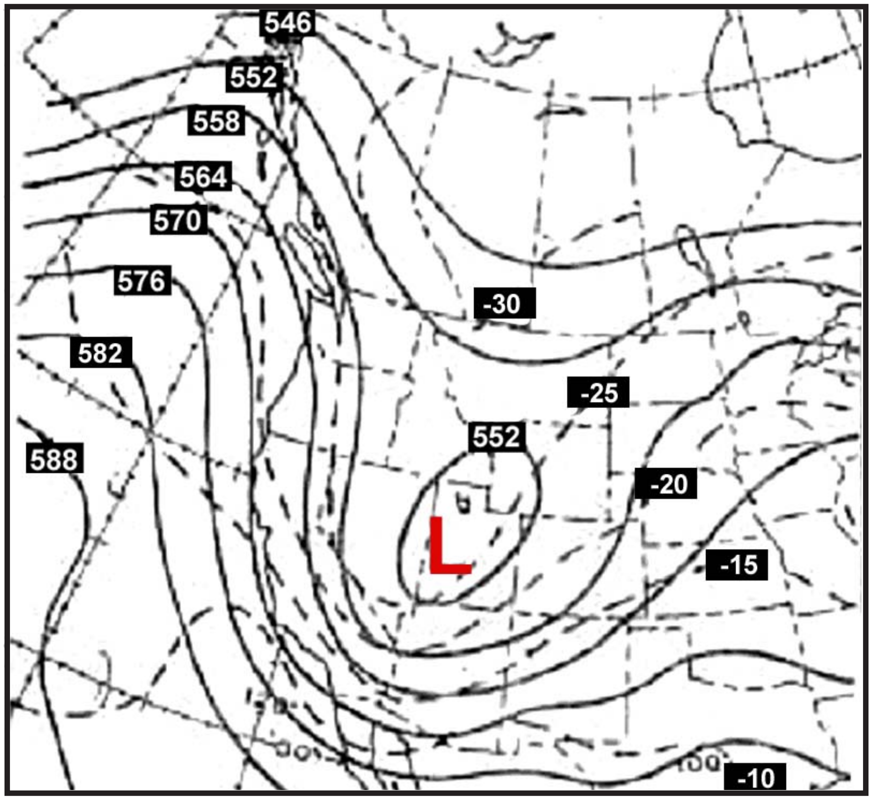

Figure 4-23. 500-mb Analysis, 1200Z/29 October 1979.

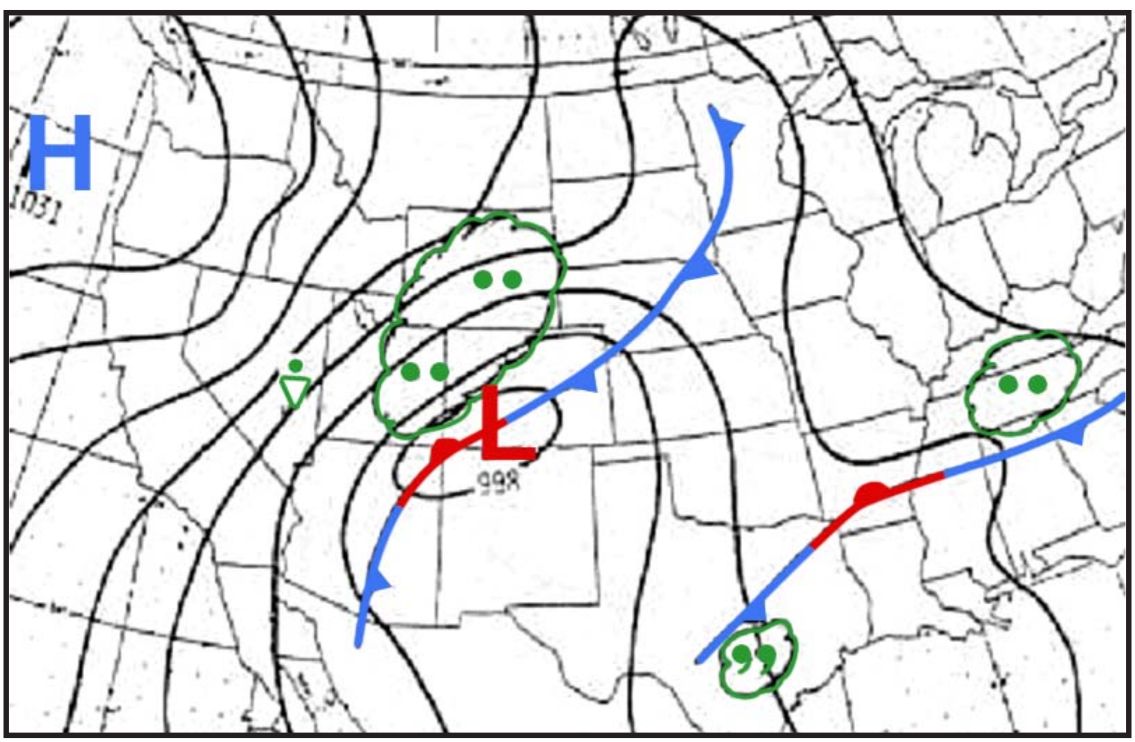

Figure 4-24. Surface Analysis, 1200Z/29 October 1979. Colorado Low will become the primary low when the upper low shown over Utah in Figure 4-23 stacks with surface low.

Figure 4-25 shows the developing storm 24 hours later than Figure 4-24.

Figure 4-26 depicts an early October winter-like storm system over the Great Plains. Snowstorms, associated with the deformation cloud system of a large comma (**C** in Figure 4-26), are responsible for most heavy snow events over and east of the Rocky Mountains and the higher elevations of the western Great Plains during autumn. The central Great Plains may expect the threat of significant snowfall by mid-November as these large comma system's deformation cloud bands track further to the east and the existing air mass is cold enough for snow to develop. The basic cloud systems of a comma system can be seen in this early morning photo: **A** -Baroclinic, **B**-Vorticity and **C**-Deformation.

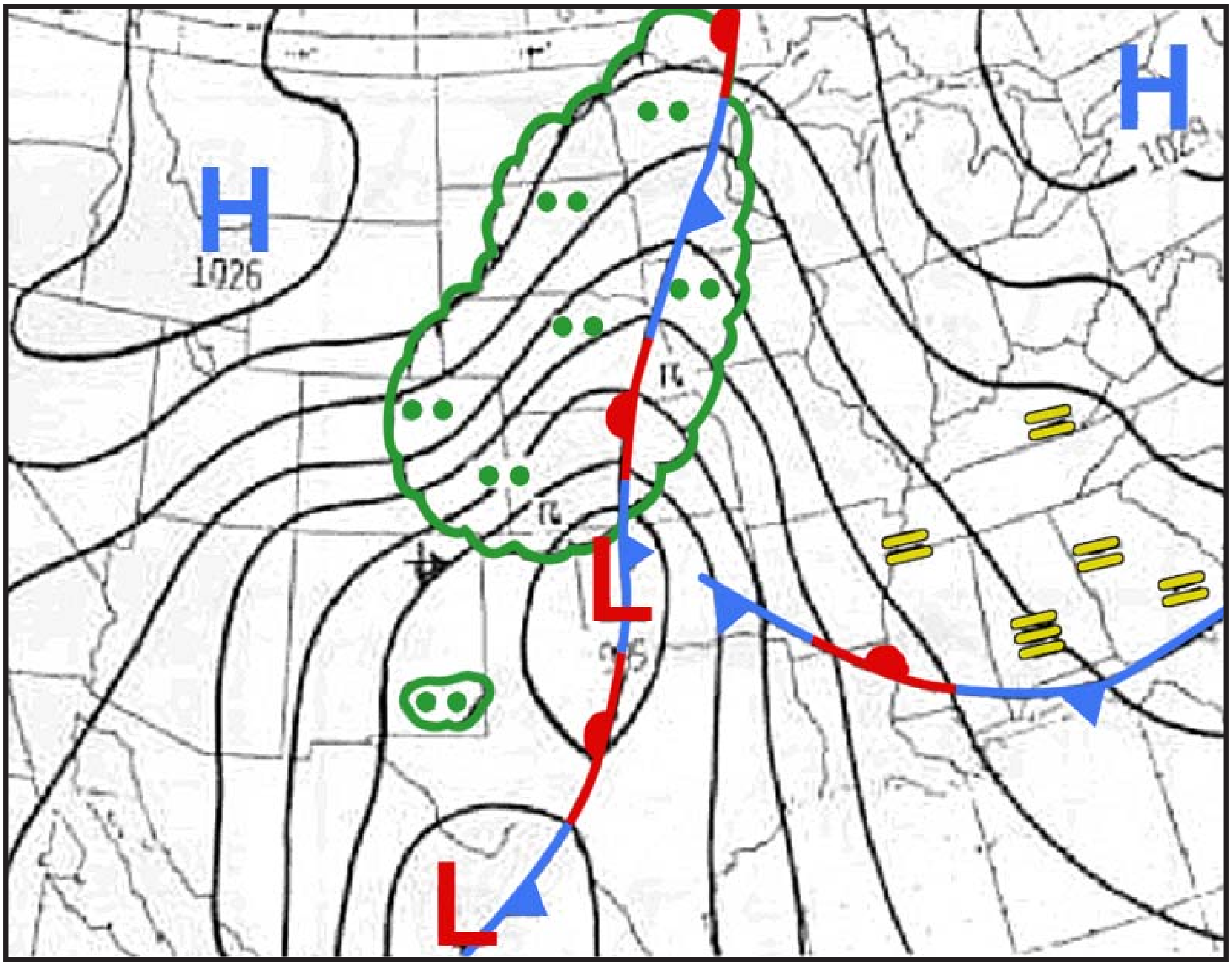

Figure 4-25. Surface Analysis, 1200Z/30 October 1979. The Colorado Low shown in Figure 4-24 has moved southeastward into Oklahoma. A receding high-pressure regime. Gulf moisture fed into the system.

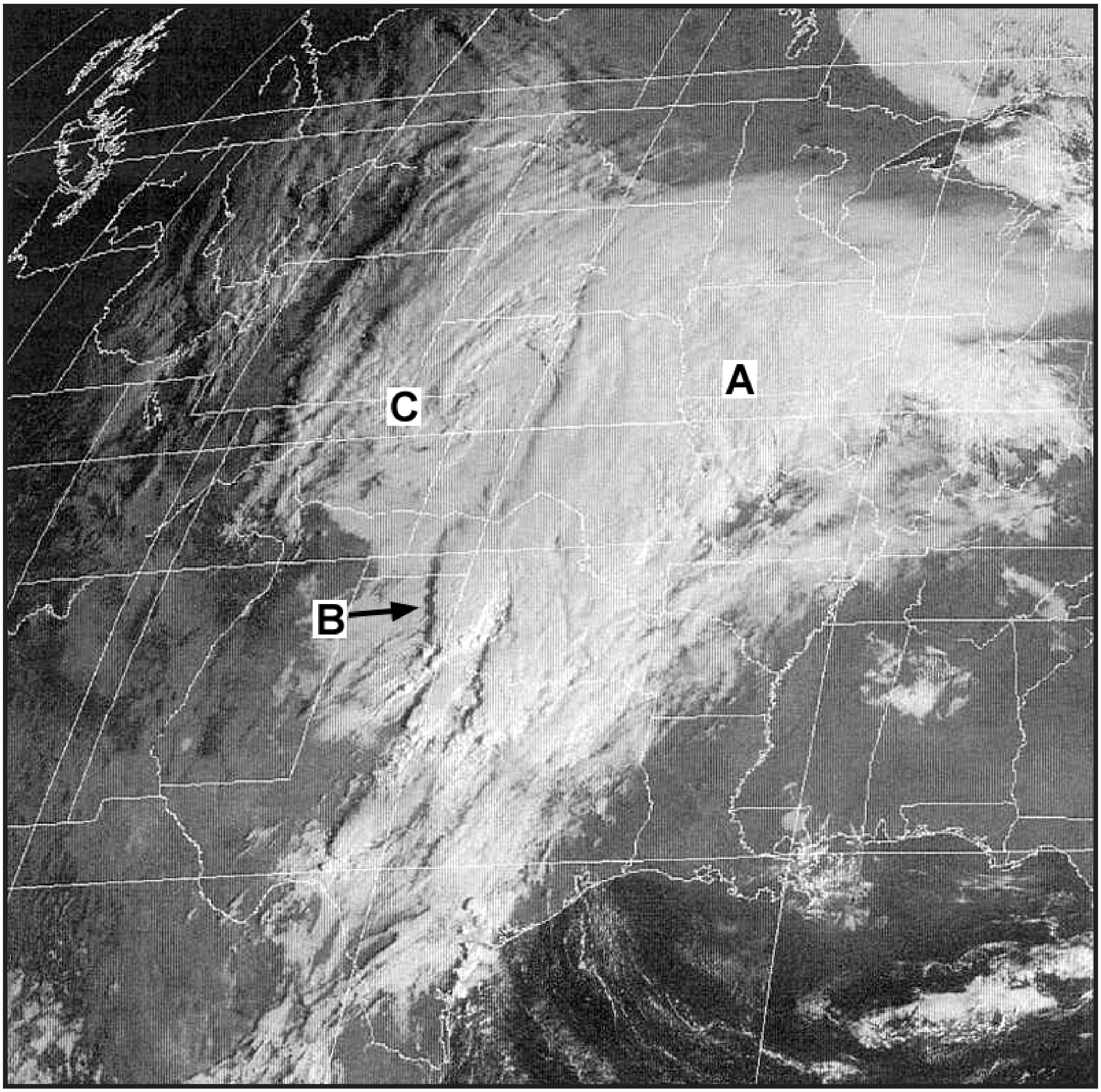

Figure 4-26. GOES East Visible, 1402Z/2 October 1998.

Figures 4-27 and 4-28 illustrate two more example of significant snowfall within deformation cloud systems over the Rocky Mountains and western Great Plains.

As mentioned above, storms that developed west of or over the Rocky Mountains generally have the potential to produce significant snowfall over central Great Plains by mid-November. Of course,

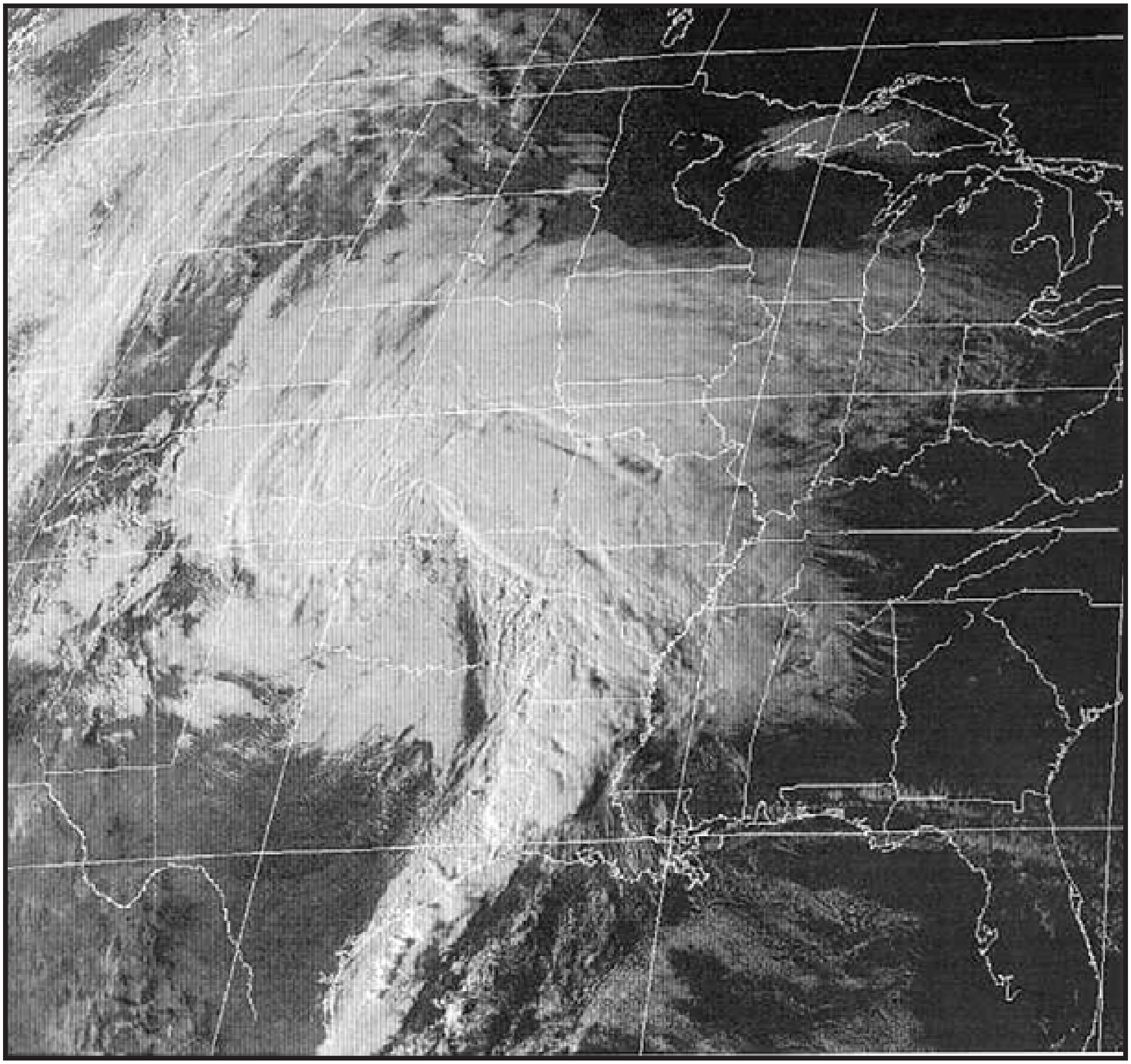

Figure 4-27. GOES East Visible, 2202Z/1 November 1998.

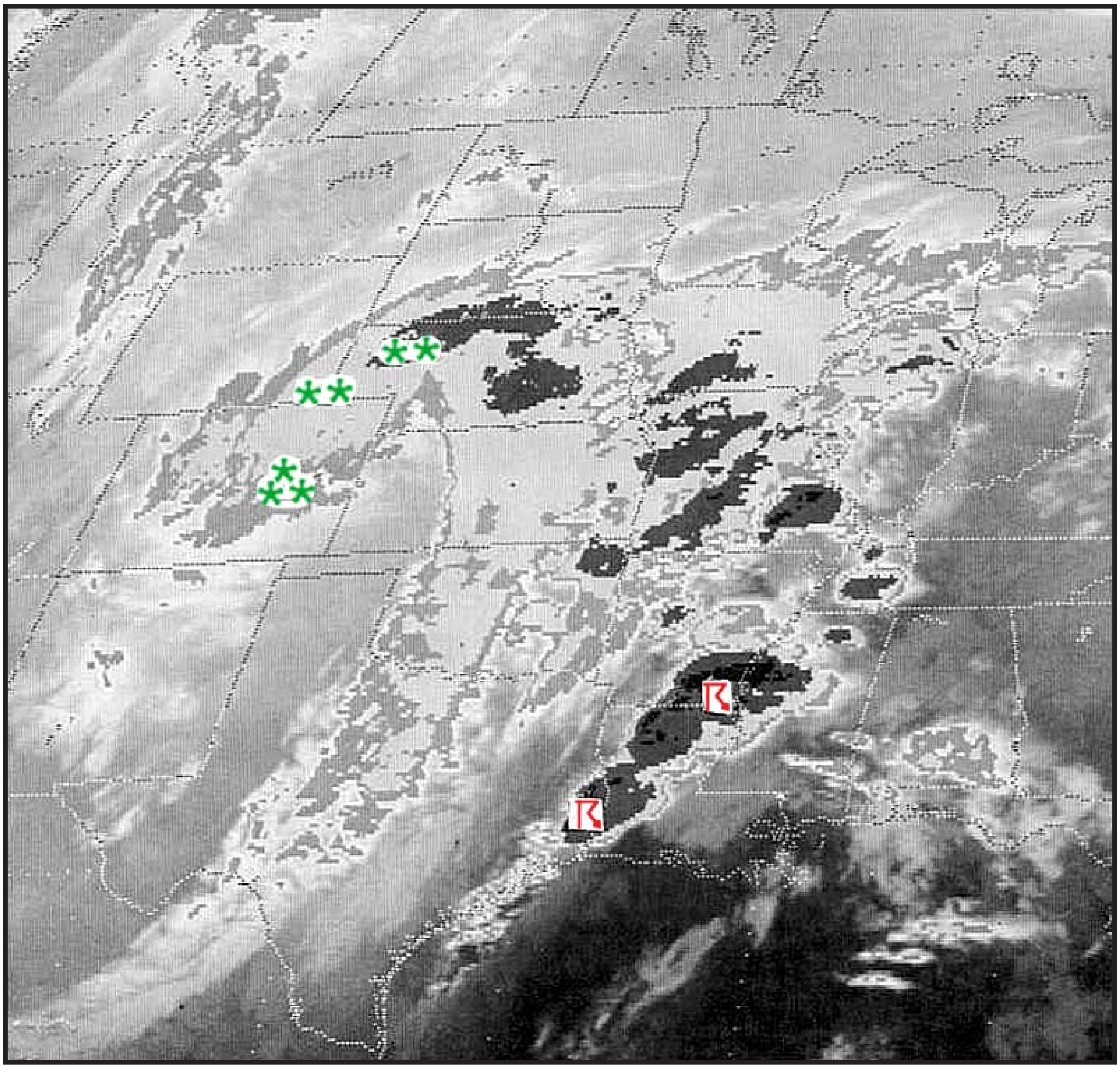

Figure 4-28. GOES East Infrared 0600Z/27 November 1983. Moderate to heavy snowfall occurred over the areas shown by the snow symbols.

there are exceptions to any weather regime as will be shown in the following late October 1997 event. The reported snow accumulations with this storm are shown in Figure 4-29. Major tree damage was reported across southeastern Nebraska and Iowa. It was a warm autumn, consequently, many trees still had their leaves. Rain fell within the warm air ahead of the emerging Rocky Mountain storm. The rain changed to heavy wet snow during the evening and continued throughout the night into the next day. The weight of the heavy wet snow accumulated on the leaves and snapped many large branches across the region.

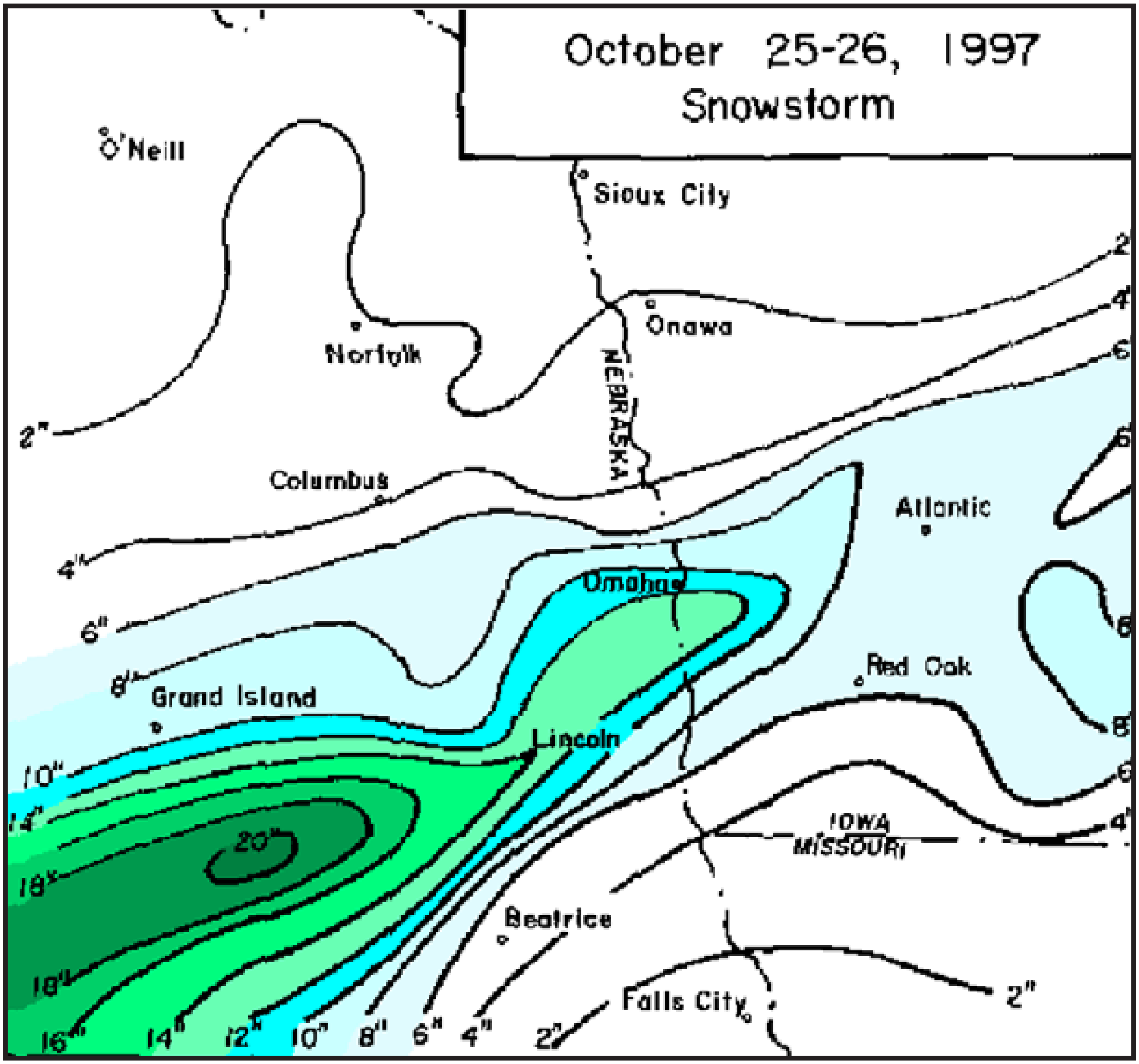

Figure 4-29. Snowfall Reports Kansas, Nebraska and Iowa, 25-26 October 1997. Greater than 10 inches fell over southeastern Nebraska and northern Kansas.

Figure 4-30 illustrates the large-scale comma over the central United States. An extensive deformation cloud system can be seen from Colorado to Iowa. The upper low began to stall over northern New Mexico. With the persistent strong upslope flow and upper-level deformation zone remaining focused over eastern Colorado and the adjacent High Plains, snowfall rates of 1-2 inches per hour were common over large portions of that region. Increasing pressure gradient between the arctic high over the northern Plains and the deepening low over the southern Plains led to strong winds and significant blowing and drifting snow. The storm began to tap low-level moisture from the Gulf of Mexico, which then wrapped around the northern portion of the storm and into the cold air, producing embedded convection that enhanced snowfall rates over Kansas and Nebraska.

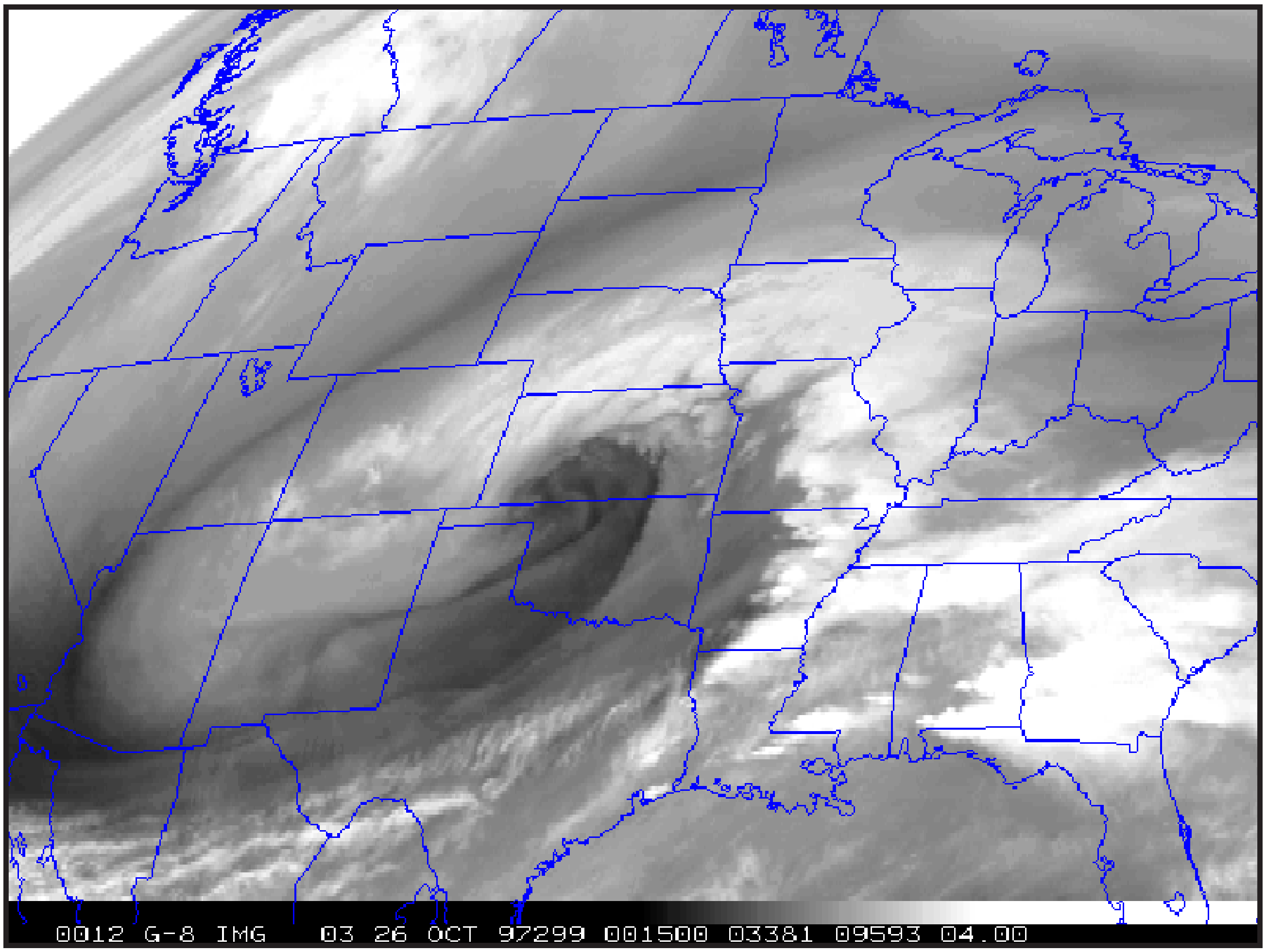

Figure 4-30. GOES East Infrared, 0300Z/26 October 1997

Southern Plains/Gulf of Mexico Cyclogenesis

Cyclogenesis regimes that occur over the southern Great Plains and the Gulf of Mexico generally begin in November as polar jets shift southward. As a result of this southward shift, continental polar air masses penetrate deep into the southern United States, Mexico and the Gulf of Mexico. Be watchful and maintain continuity on developing upper lows that appear over the southwestern United States (Figure 4-31). These lows are often associated with significant storm and precipitation events that develop across the southern United States In Figure 4-32, a large prevailing high-

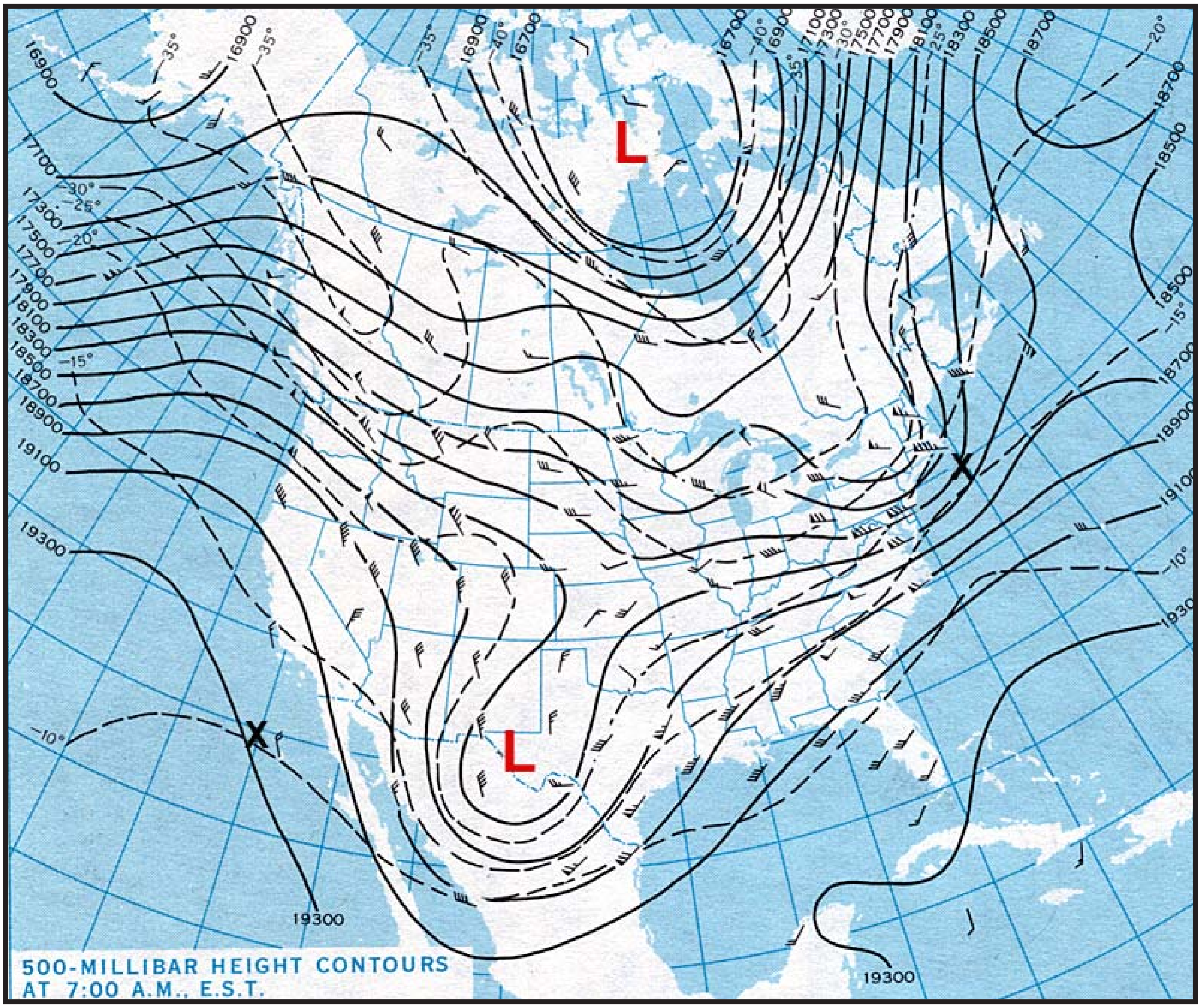

Figure 4-31. 500-mb Analysis, 1200Z/26 November 1980.

pressure regime appears over most of the nation. This regime is more frequent during January and February, however, gulf polar front cyclogenesis may occur by late autumn as shown in this event.

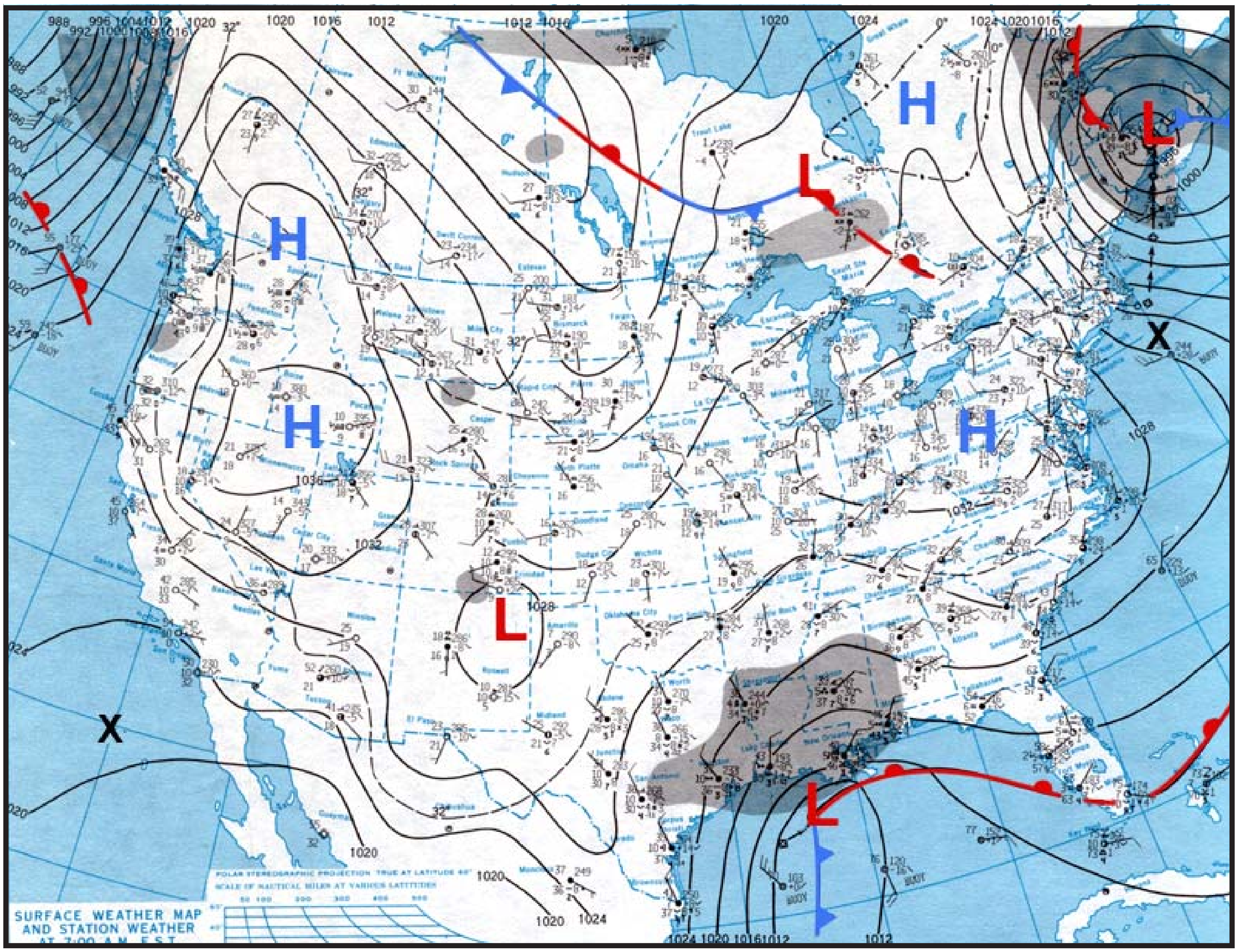

Figure 4-32. Surface Analysis, 1200Z/26 November 1980. Gulf wave has developed in response to the approaching upper short wave.

CUTOFF LOWS

Cutoff low discussions were presented earlier in Chapter 2. Another example is shown in the following illustrations, which will show satellite interpretations of a developing cutoff low over the Great Plains. Figure 4-33 depicts the IR image approximately 12 hours before upper low development. A short wave vorticity system, located over the central Rockies is moving towards a baroclinic zone cloud system that is stationary from Texas to the Great Lakes. The inset in Figure 4-33 shows the short wave; the **X** approximates the vorticity center.

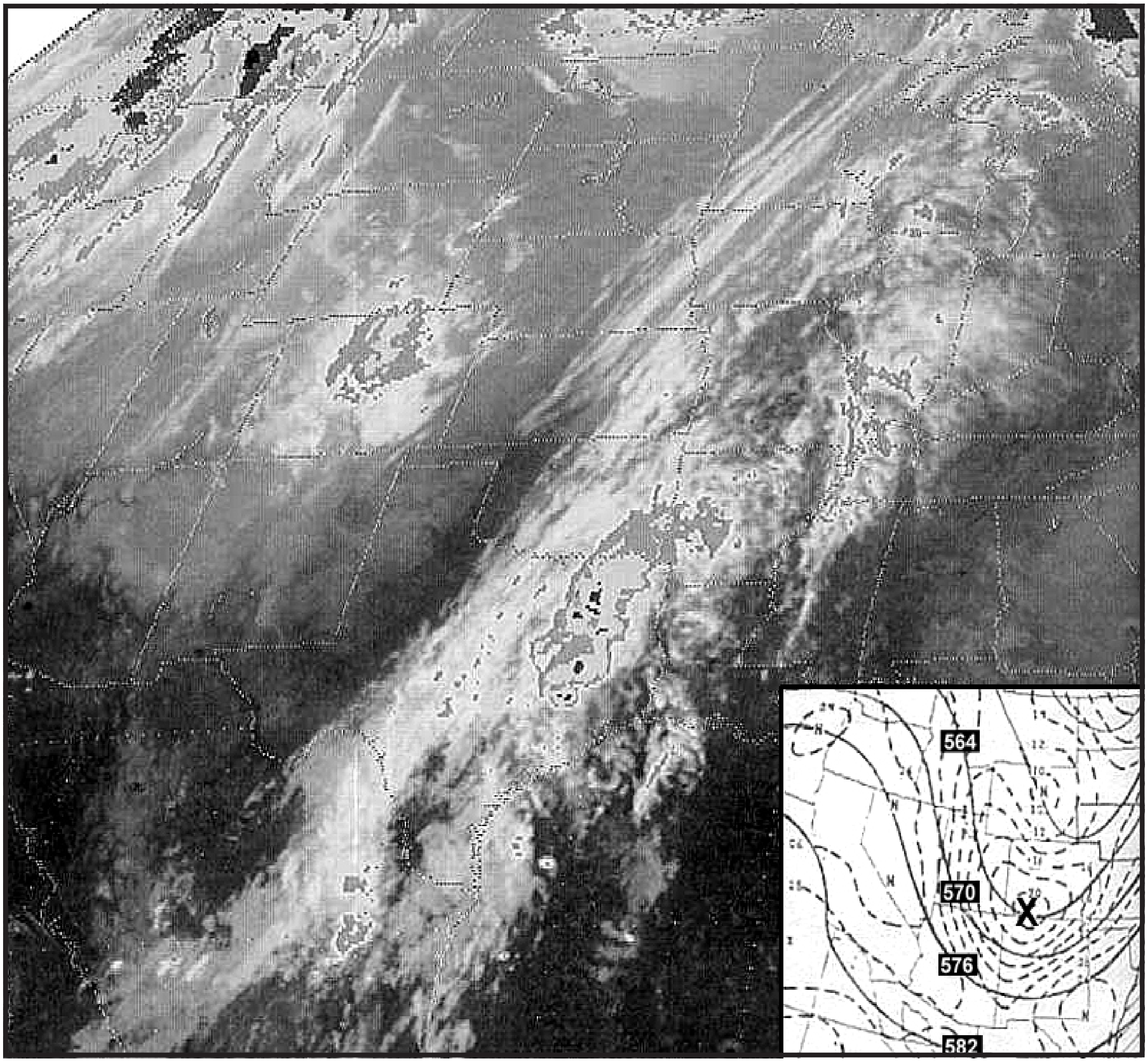

Figure 4-33. GOES East Infrared, 0000Z/31 October 1981. Inset: Initial 500-mb Heights/Vorticity, 0000Z/31 October 1981.

Approximately 15 hours later (Figure 4-34), the vorticity system reaches western Kansas and northwest Texas. The northeast-southwest alignment and wispiness of the clouds associated with the vorticity system (see arrow in Figure 4-34) indicates the formation of an upper-level low. The cloud system is developing into the deformation zone of a comma cloud as shown in the inset in Figure 4-35. Nine hours later (Figure 4-35), the infrared image clearly reveals the deformation cloud zone (noted by **C** in Figure 4-35). The deformation cloud system has expanded across the western Great Plains suggesting that an upper low has formed.

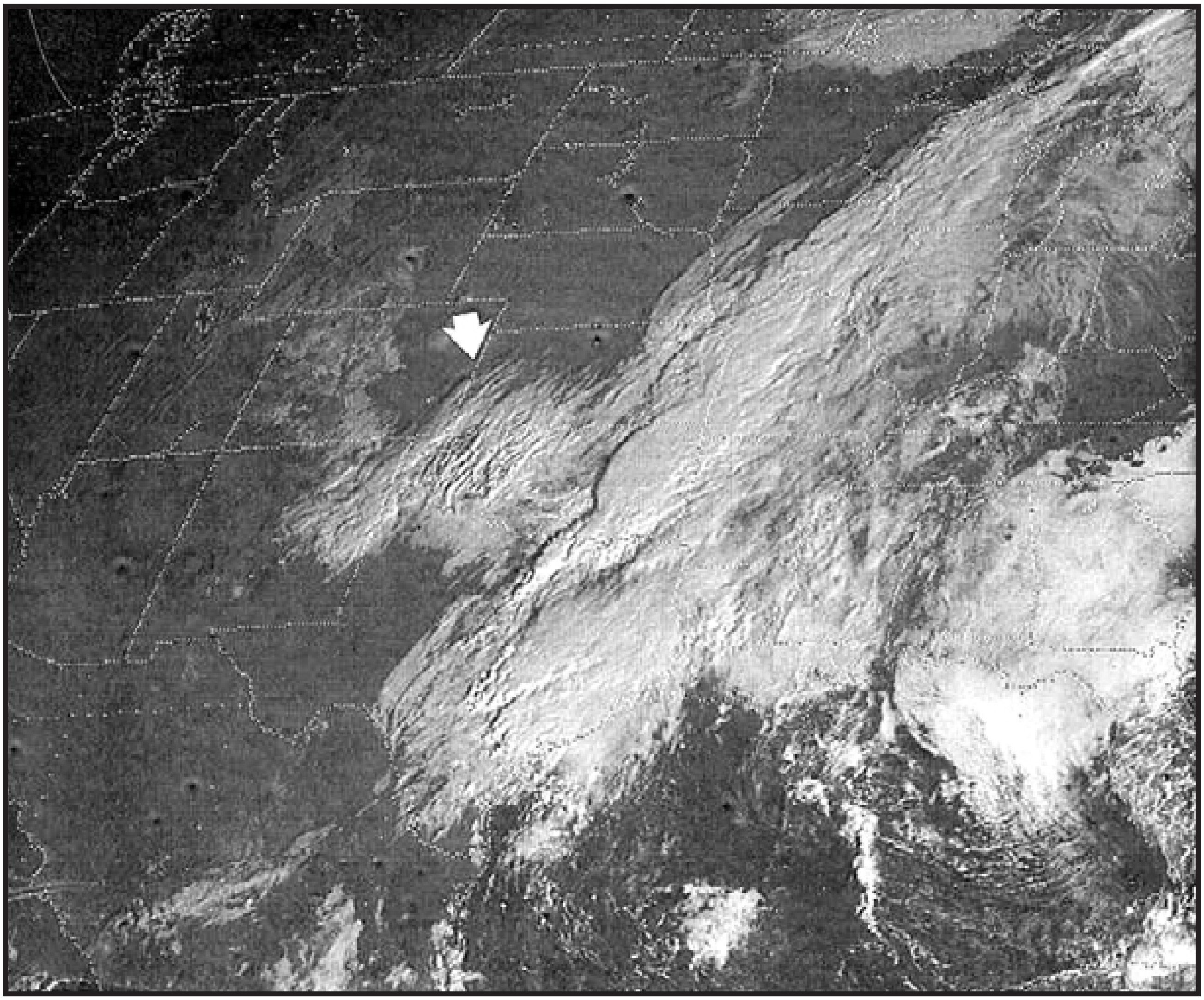

Figure 4-34. GOES East Visible, 1430Z/31 October 1981. Arrow points to a deformation cloud system associated with a developing upper low

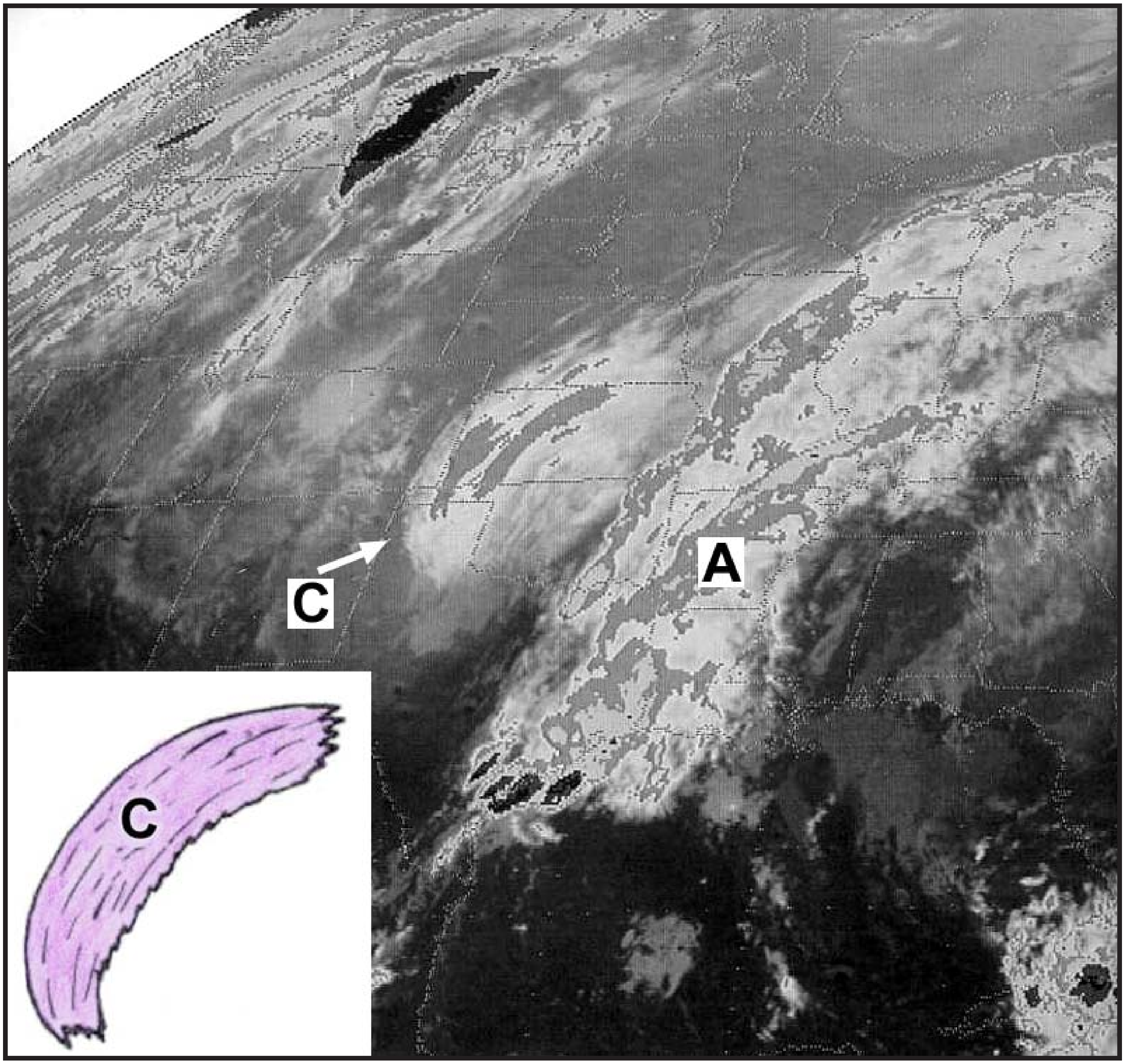

Figure 4-35. GOES East Infrared, 2300Z/31 October 1981. Inset: Model of Weldon's deformation zone of a comma system.

Thirteen hours later (Figure 4-36), the infrared image reveals a cyclonic circulation with the borders of the deformation cloud better defined. The related 500-mb analysis (shown in the inset of Figure 4-36) shows a blocking high/cutoff low pattern has evolved over the southern Great Plains.

A later visible image (Figure 4-37), shows a mature cutoff low system. Cutoff low systems are generally slow-movers due to the absence of the prevailing polar jet stream (located further to the north). This blocking high/cutoff low pattern is typical during autumn.

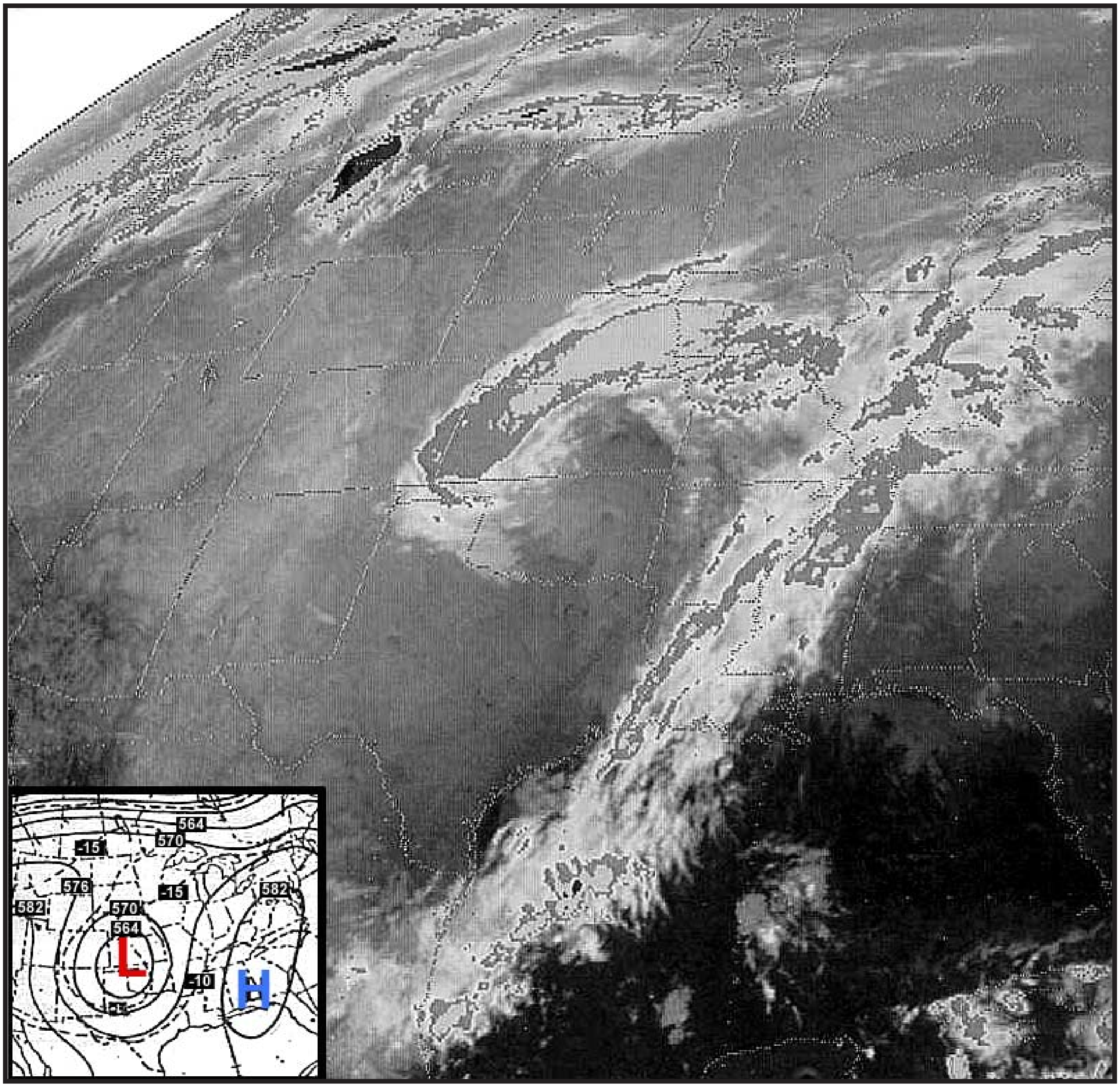

Figure 4-36. GOES East Infrared, 1200Z/1 November 1981. Inset: 500-mb Analysis, 1200Z/1 November 1981.

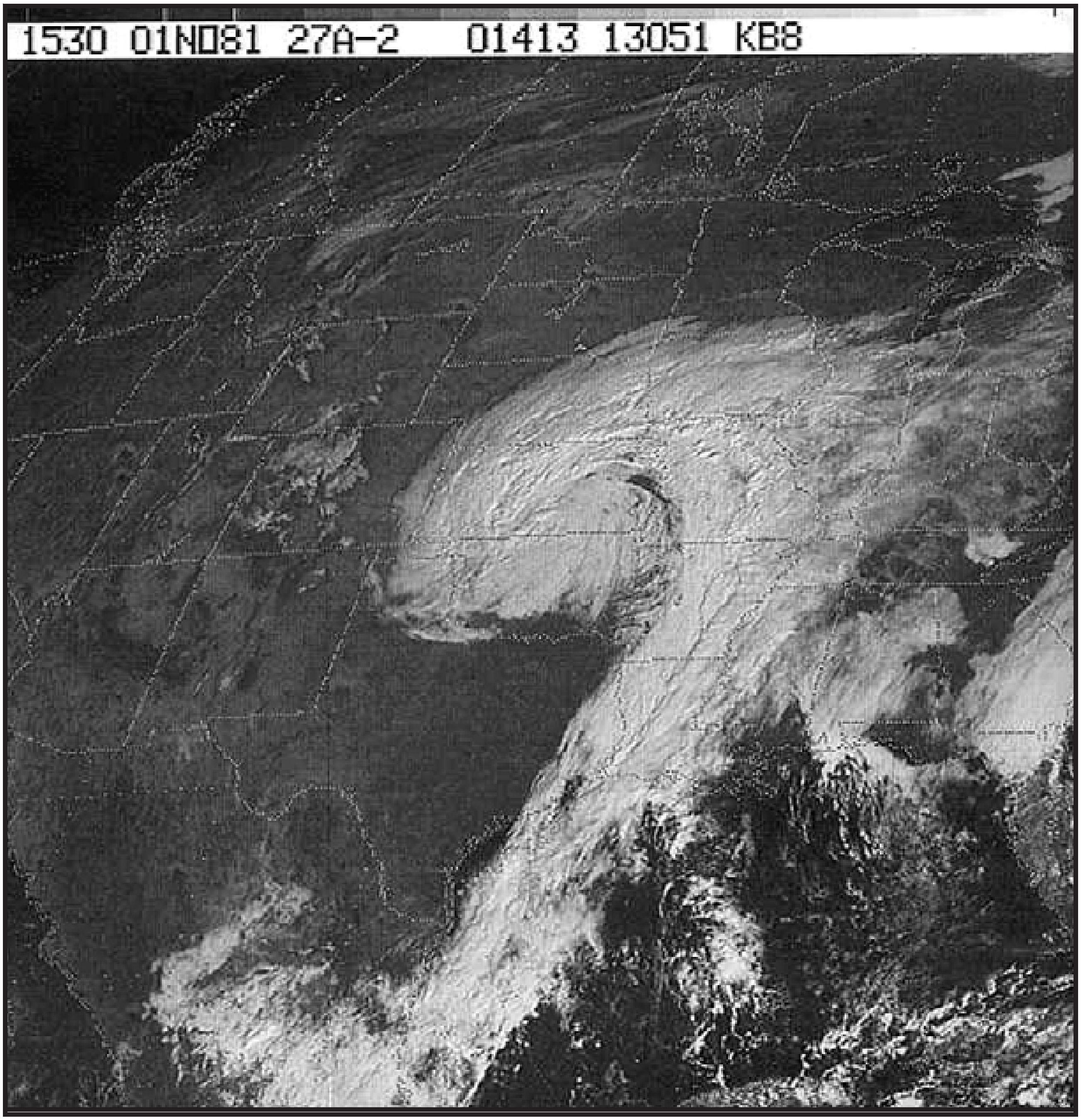

Figure 4-37. GOES East Visible, 1530Z/01 November 1981. A well-defined cutoff low system has evolved.

Forty-eight hours later (Figure 4-38), the system appears over the same general area but shows signs of dissipation. Mature cutoff lows often become barotropic and begin to dissipate. The 500-mb height/vorticity analysis shown in the inset in Figure 4-38 reveals that the vorticity isopleths are in phase with the contours – little or no baroclinicity can be found. Locations affected by these stagnant systems may experience the same weather conditions for several days in a row. Significant rainfall can be expected within these slow-moving systems; they may become stationary over the same area for several days before they began to weaken or dissipate.

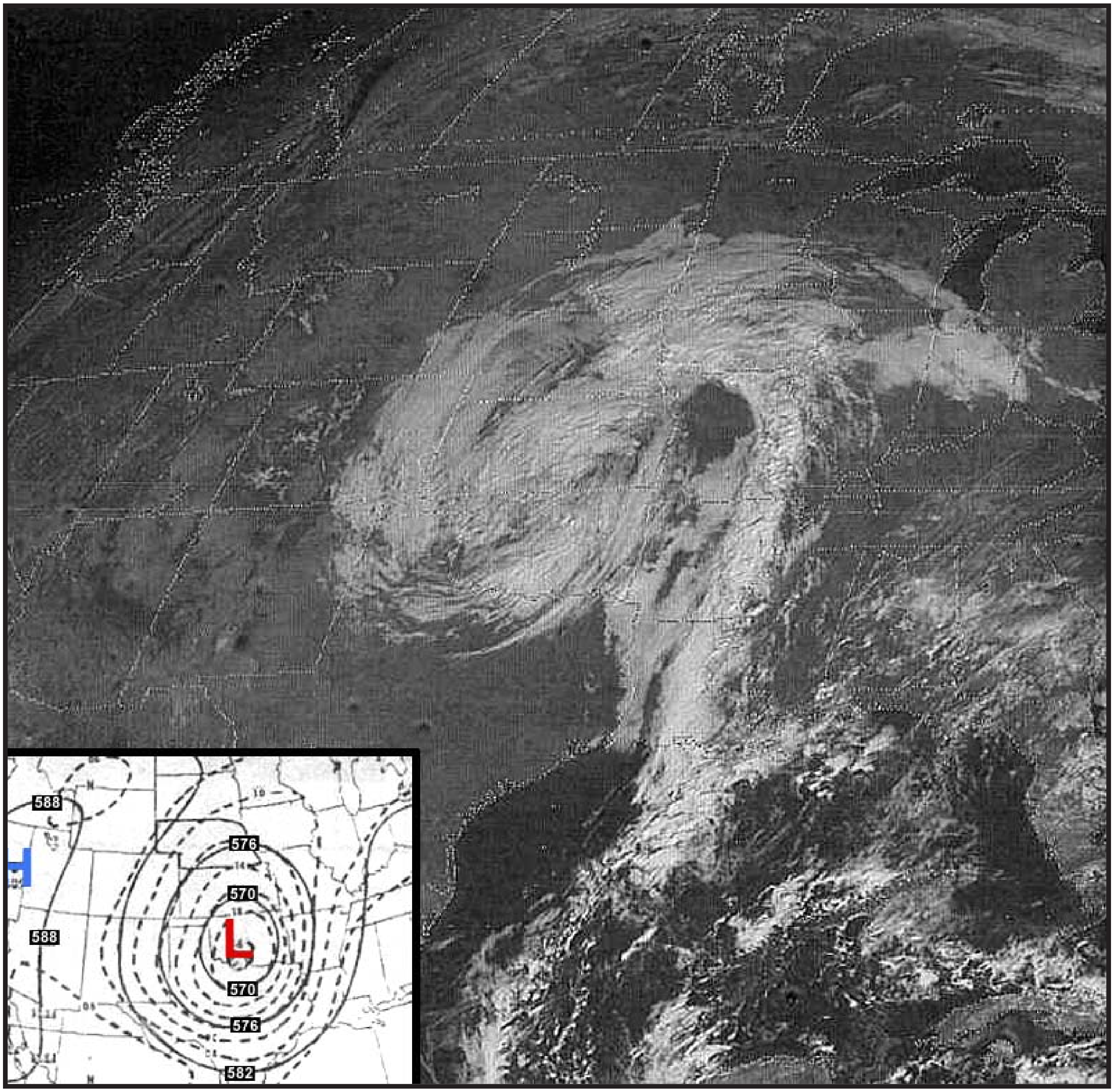

Figure 4-38. GOES East Visible, 1530Z/3 November 1981. Inset: 00-Hour, 500-mb Heights/Vorticity, 1200Z/3 November 1981.

LOW-LEVEL JET/GULF MOISTURE ADVECTION.

Occurrences of low-level jet activity increase across the Great Plains during October (Figure 4-39). Synoptically, low-level jet intensification is attributed to a strengthening south to north pressure gradient across the Great Plains. This tightening of the gradient is primarily caused from an increase in mP pacific air masses that move across the Great Plains and development of surface troughs in the lee of the Rockies and western Great Plains. Lee-side troughs appear when southerly winds advect warmer air northward as mP air masses recede from the central Great Plains. Figure 4-40 illustrates the surface conditions related to the low-level jet shown in Figure 4-39. In Figure 4-40, the lee-side trough shown over the Western Plains had earlier drifted eastward from its usual position in the lee of the Rockies.

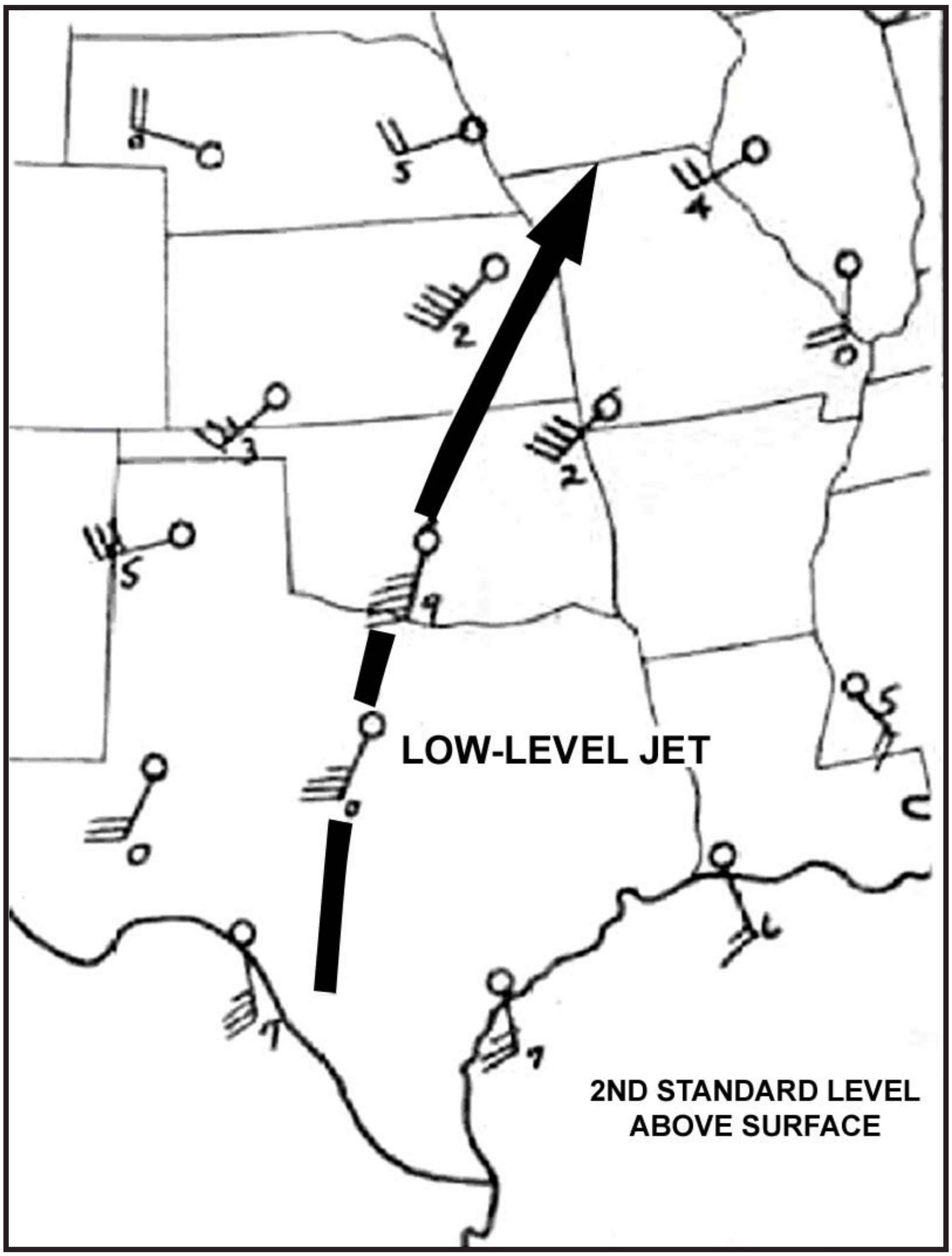

Figure 4-39. Low-Level Jet, 1200Z/15 October 1979. 2nd Standard Level.

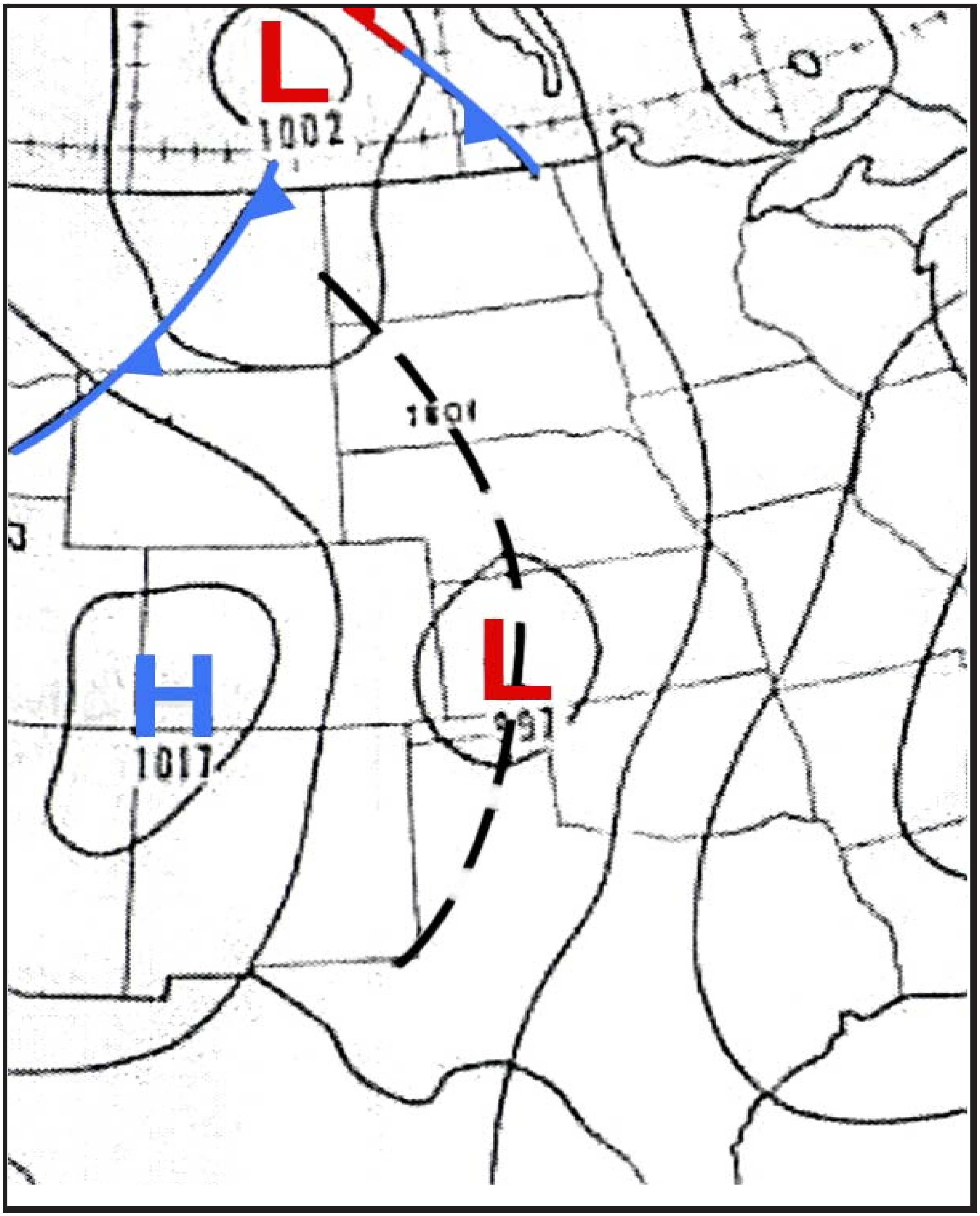

Figure 4-40. Surface Analysis, 1200Z/15 October 1979. Related to Figure 4-39.

In Figure 4-41, gulf stratus advection can be seen from east Texas to Kansas. Gulf stratus has "met" the approaching mP cold front over eastern Kansas. Note that the stratus advection event shown in Figure 4-41 is approximately 24 hours after low-level jet formation depicted in Figure 4-39.

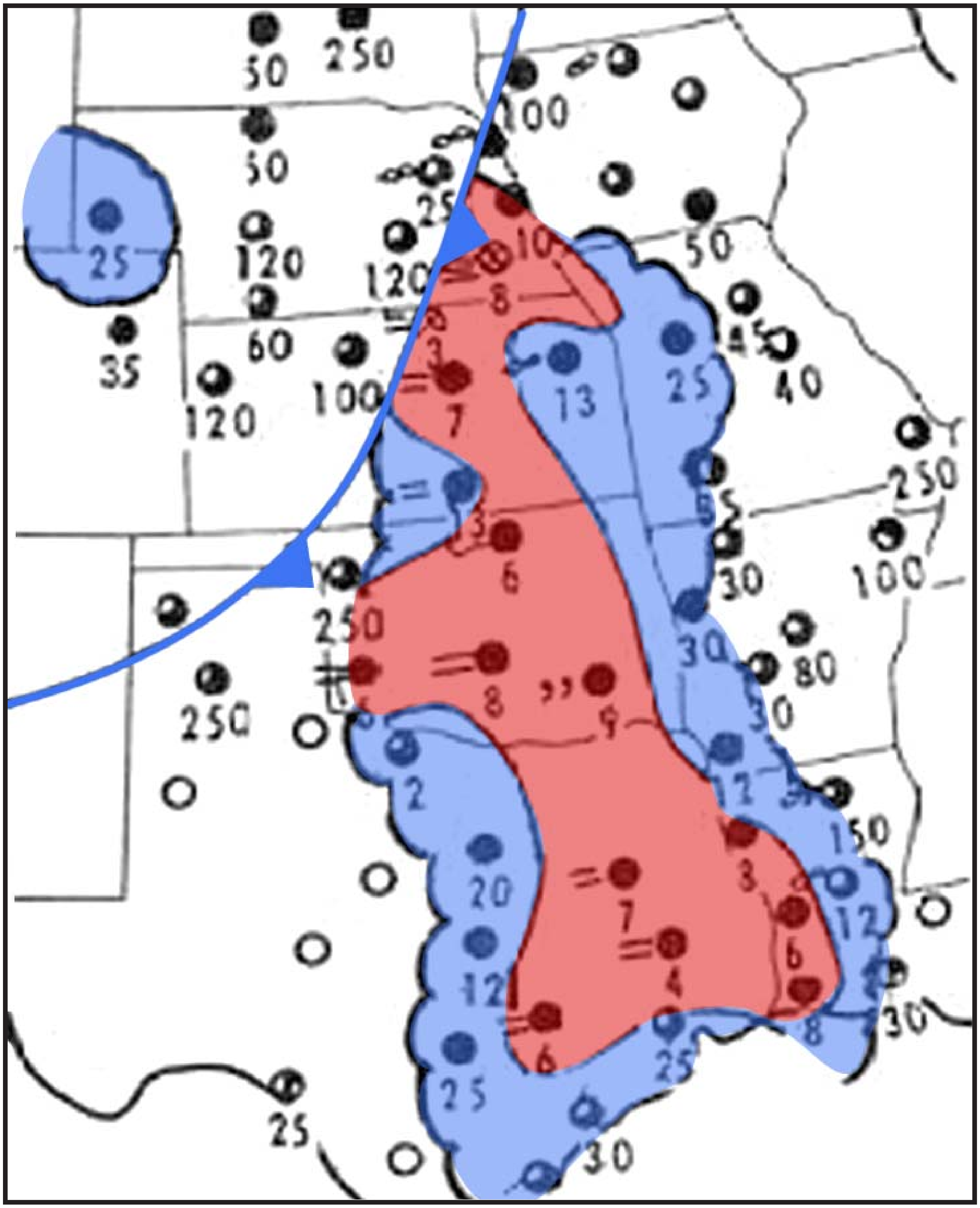

Figure 4-41. Nephanalysis, 1600Z/16 October 1979. The scalloped area represents ceiling heights less than or equal to 3,000 feet.

Figure 4-42 confirms the tongue of gulf moisture across eastern Texas, Oklahoma and Kansas; stratus formation and advection was almost entirely over land as seen in the visible photo. **Caution**: Low-level jet development and subsequent gulf stratus advection does not occur ahead of every mP front emerging from the Rocky Mountains. The chances for stratus advection increase when these fronts slow down sufficiently to allow the synoptic events shown in Figures 4-39 and 4-40 to become established.

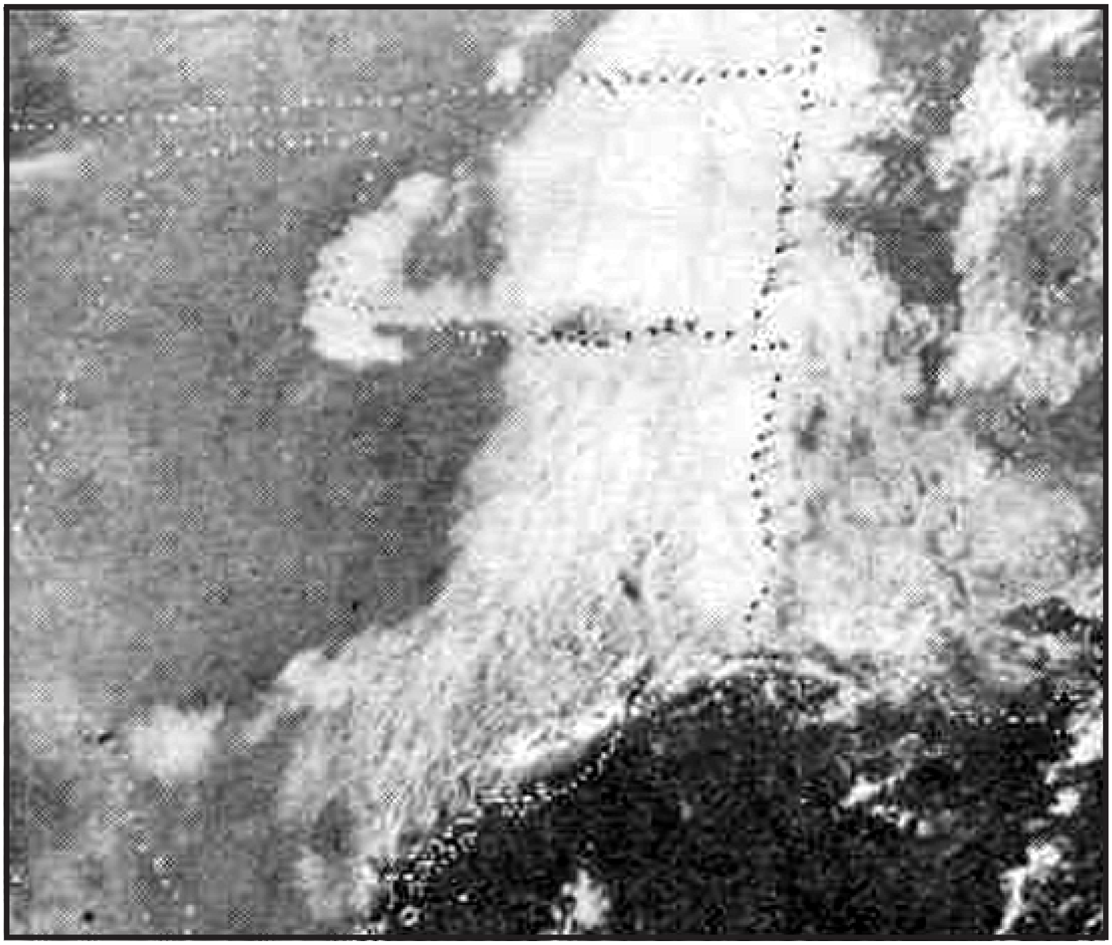

Figure 4-42. GOES East Visible, 1715Z/16 October 1979. This figure is related to Figures 4-39 through 4-40 and shows the tongue of gulf moisture advection into Texas, Oklahoma and Kansas.

Forecasting the strength of the low-level jet maximum wind speeds is difficult using analysis data. Numerical model forecast products are helpful. An empirical method for forecasting the maximum strength of the nocturnal low-level jet was developed from four years of data over the central and southern Great Plains many years ago. Figure 4-43 gives the relationship of the 0000Z Amarillo (AMA) and Ft. Worth-Dallas (FWD) 850-mb gradient and the forecast 0600Z low-level maximum winds over Oklahoma City (OKC), which would be representative all along the jet stream corridor. The method is usable within a south to north flow (no frontal/trough intrusions to disrupt the gradient).

850 MB
GRADIENT/SPEED RELATIONSHIP
AMA - FWD

Initial 0000Z DM (METERS)	Fcst 0600Z JET SPEEDS
40 - 60	30 - 40K
60 - 75	40 - 50 K
75 - 90	50 - 60K
≥90	>60

Figure 4-43. 850-mb Gradient/Speed Relationship

Figure 4-44 is a vertical wind profile of low-level jet activity over the Oklahoma City region (OKC sounding) a few years ago. The wind speed increased from 30 knots to 60 knots at 4,000 feet between 0000Z and 1200Z. In the 1200Z vertical wind profile the slight decrease in wind speed at 7,000 feet probably is the defining layer between the top of the low-level jet and the bottom of the mid-level jet. Vertical wind profiles can also be routinely obtained from the WSR-88D Doppler radar vertical wind profile (VWP) product and wind profilers that are in place across the Great Plains.

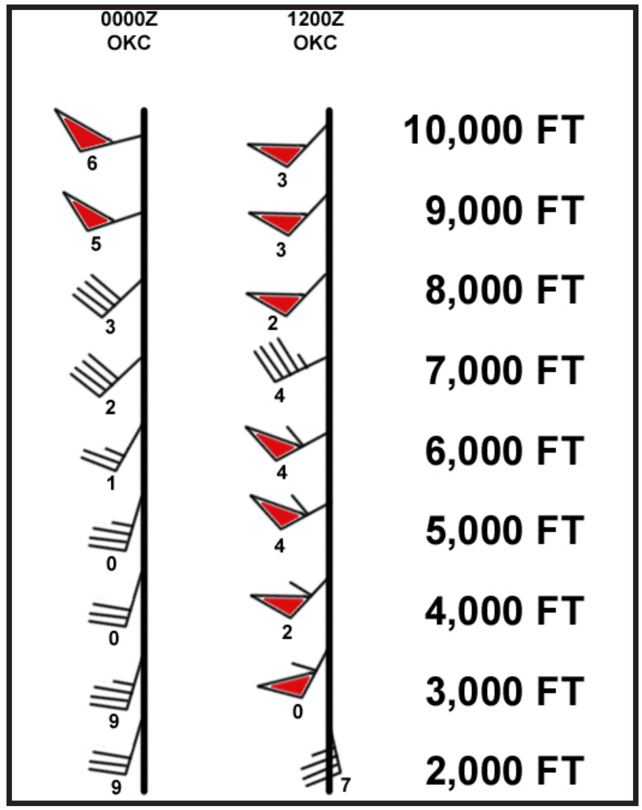

Figure 4-44. Vertical Wind Profile from Oklahoma City, Oklahoma Radiosonde Observation.

Gulf Moisture Advection Track – Type 2

A considerable amount of discussion and empirical rules on low-level jet development and three primary gulf moisture tracks over the central Great Plains is presented in Winter Regimes. Of these three tracks, Type 2 is the most common track during autumn. Figure 4-45 depicts Type 2 advection (extracted from Winter Regimes).

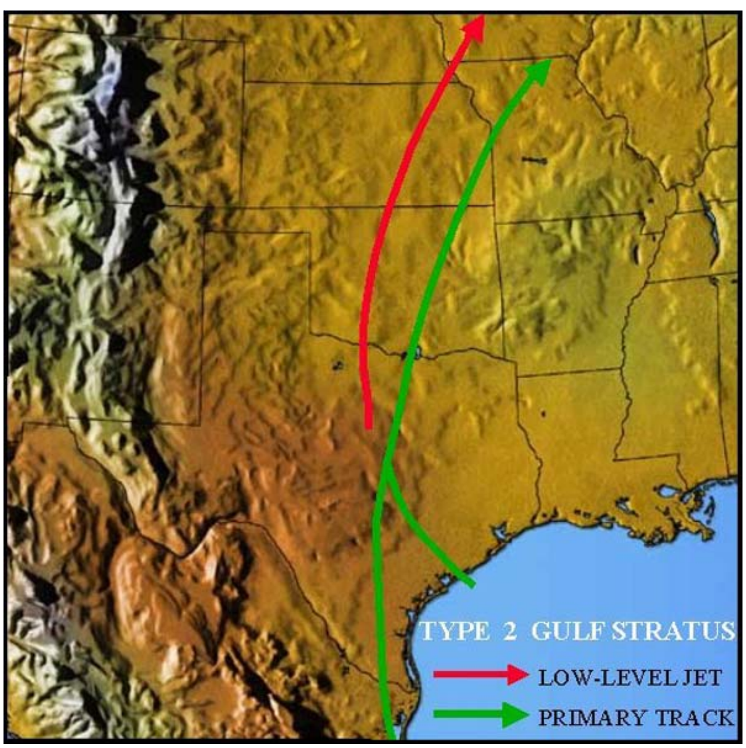

Figure 4-45. Type 2 Gulf Stratus Advection

Figures 4-46 through 4-48 illustrate three more examples of Type 2 Gulf of Mexico stratus advection that occurred over the Great Plains during autumn.

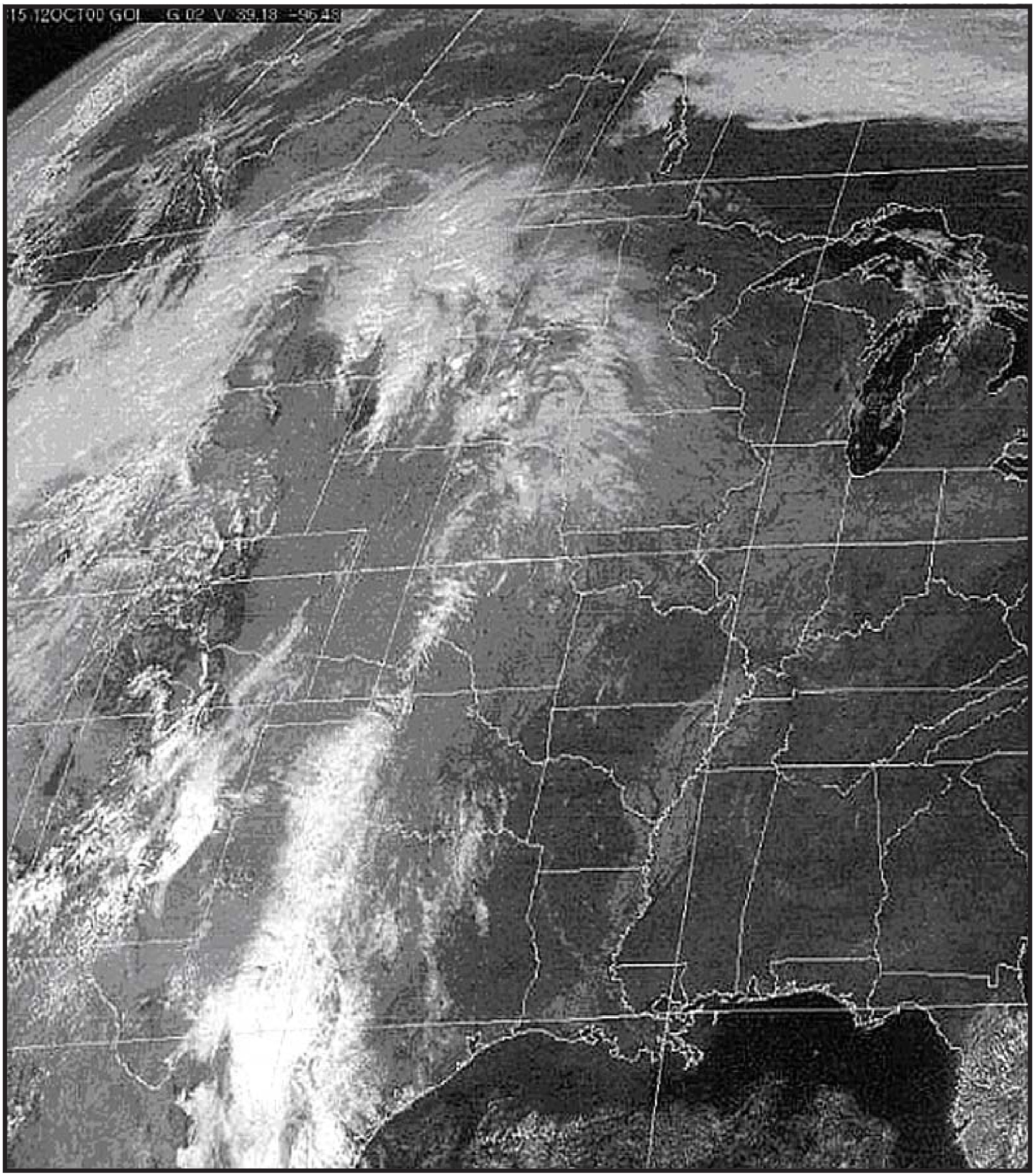

Figure 4-46. GOES East Visible, 1815Z/12 October 2000

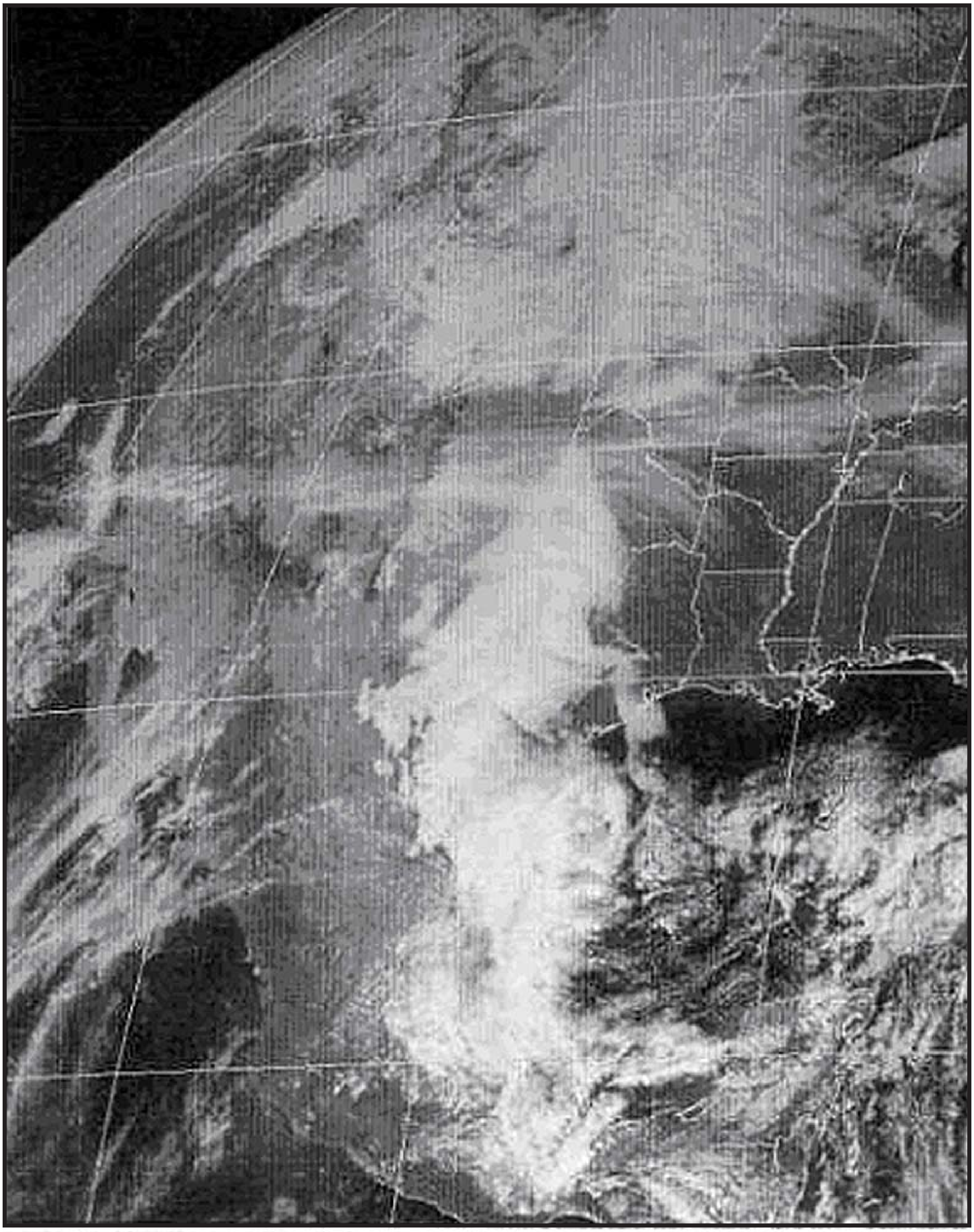

Figure 4-47. GOES East Visible, 1845Z/5 December 2000

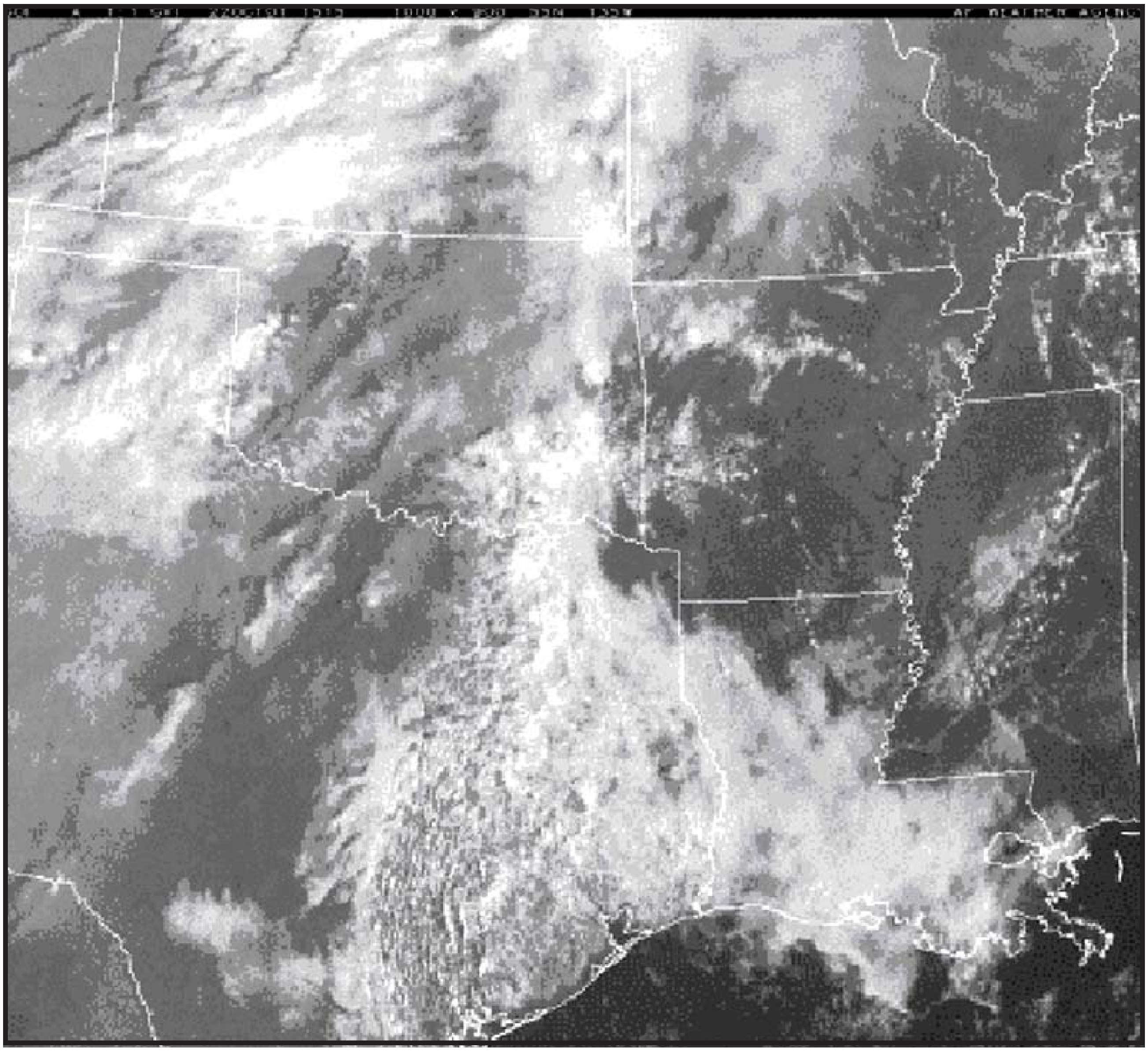

Figure 4-48. GOES East Visible, 1515Z/22 October 2001. Nearly all stratus formed over the land.

CONTINENTAL POLAR AIR REGIME.

By late October or early November, an occurrence of a winter-like, intense polar air mass from Canada, penetrating deep into the central and southern United States is likely (Figure 4-49). Widespread precipitation is likely to occur from the western polar frontal boundary and eastward across the Great Plains. Precipitation intensity and coverage is dependent upon the strength of overrunning of a moist, southwest mid-level Pacific airflow and warmer more moist southeast low-level flow from the Gulf of Mexico. Persistent upslope flow across the western Great Plains increases precipitation amounts. Freezing precipitation (mostly drizzle) is occasionally reported over the extreme western plains and in the lee of the Rocky Mountains.

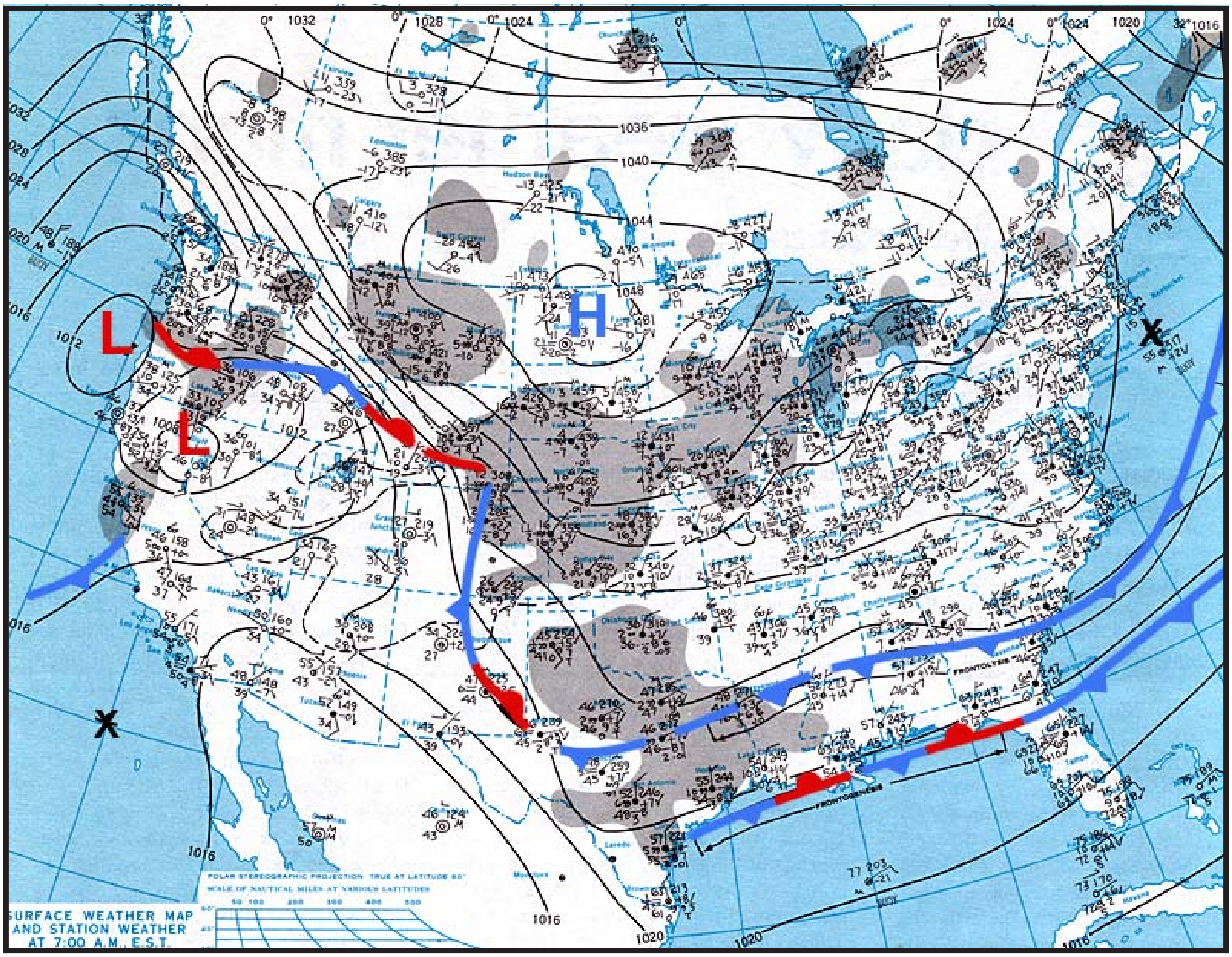

Figure 4-49. Surface Analysis, 1200Z/20 November 1978

Figure 4-50 illustrates an early autumn regime of a stagnant continental polar air mass (often a prevailing high pattern) that has produced an extensive area of low ceilings, fog and precipitation (mostly overrunning) across the southern and central United States. Often, post-frontal stratus (residual stratus) stagnates over Texas, as the front becomes stationary as shown in Figure 4-50. Also, upslope cloud systems develop over the western Great Plains and spread eastward as Gulf moisture overruns the shallow air mass. These synoptic regimes may persist for several days or, perhaps, for a week before the pattern changes

NON-CONVECTIVE SURFACE WIND REGIMES (NOTORIOUS WIND BOXES).

Northern Great Plains Box. Southeastward moving storms such as shown earlier in the Alberta Low regime often trigger the Livingston Box and later activating the Northern Plains Box. Because surface wind gusts do not confine themselves to the basic Livingston box as the storm system tracks eastward, this becomes an important storm track. Figure 4-51 depicts a northern Great Plains Alberta low storm track. A typical low-level maximum wind chart is shown in Figure 4-52.

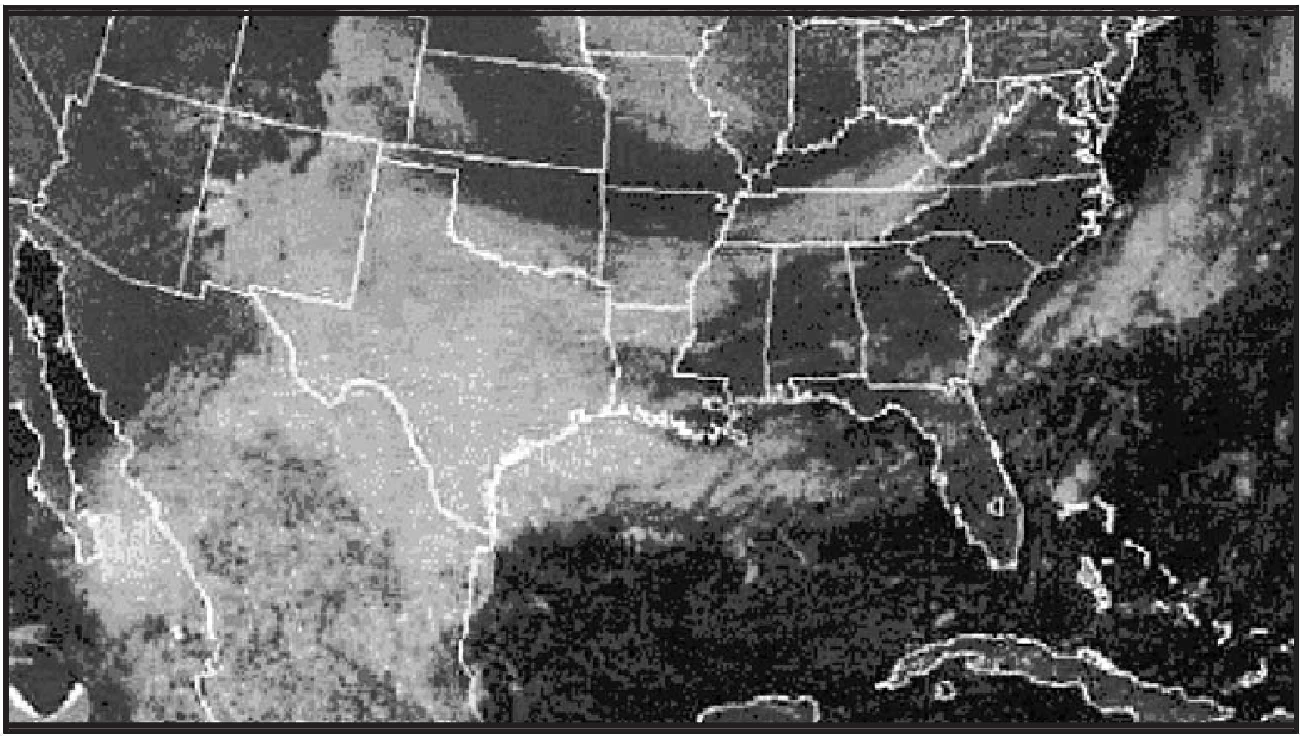

Figure 4-50. GOES East Visible, 1845Z/7 October 2000. Extensive stratus is shown over Texas and eastern New Mexico and Colorado.

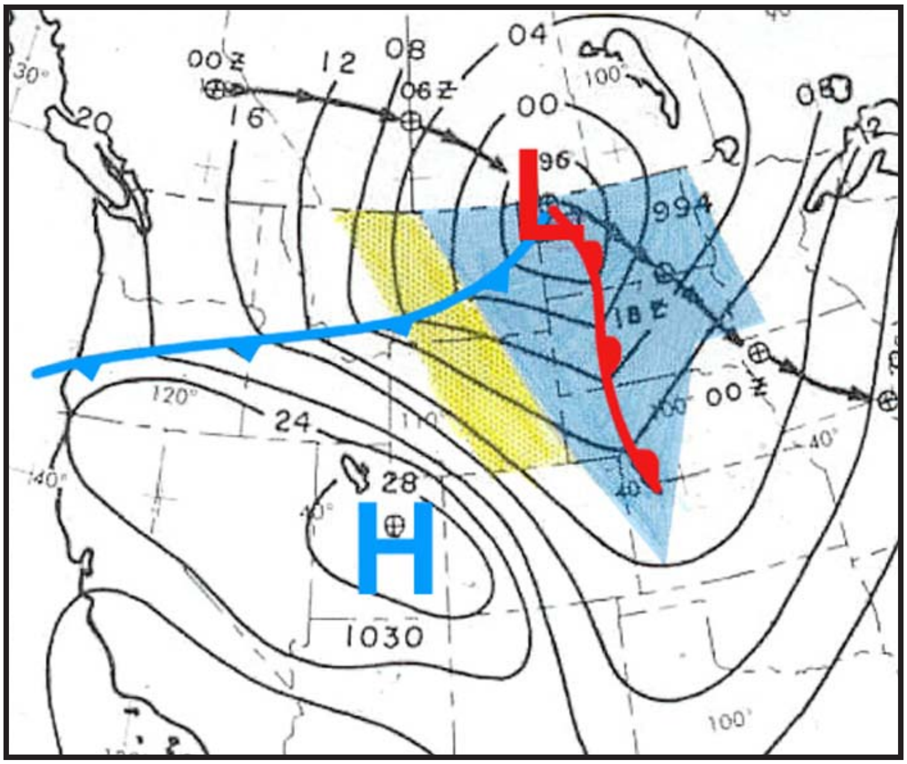

Figure 4-51. Livingston and Northern Plains Boxes Surface.

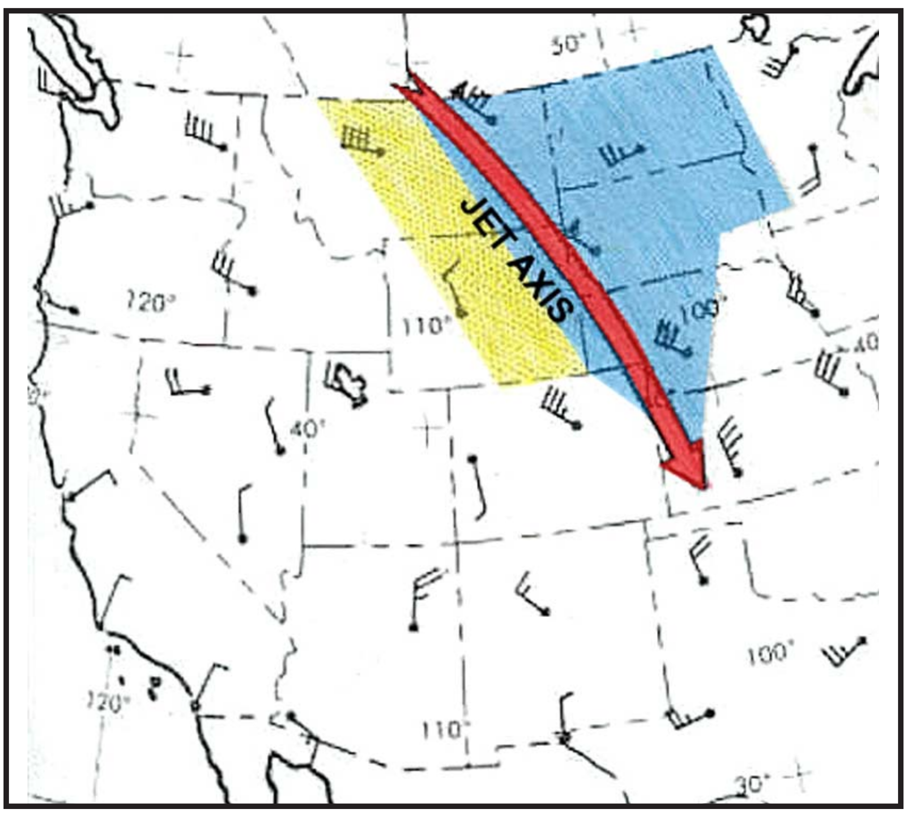

Figure 4-52. Livingston and Northern Plains Boxes Low-Level Maximum Winds.

Another Northern Plains wind event that should be considered is shown in Figure 4-53. Rapid-moving secondary troughs following a cold frontal passage are capable of activating the Northern Plains Box. In Figure 4-53, tight isobaric packing and isobars with a northwest-southeast orientation are shown. Moderate-to-strong surface-pressure change rise centers and their continuity of movement are very important to forecast a wind outbreak (see inset in Figure 4-53). There is an empirical rule that uses the time the rise center crosses the Canadian borders to predict the onset of 35 knot gusts after sunrise (see inset in Figure 4-53; from AWS-TR-219).

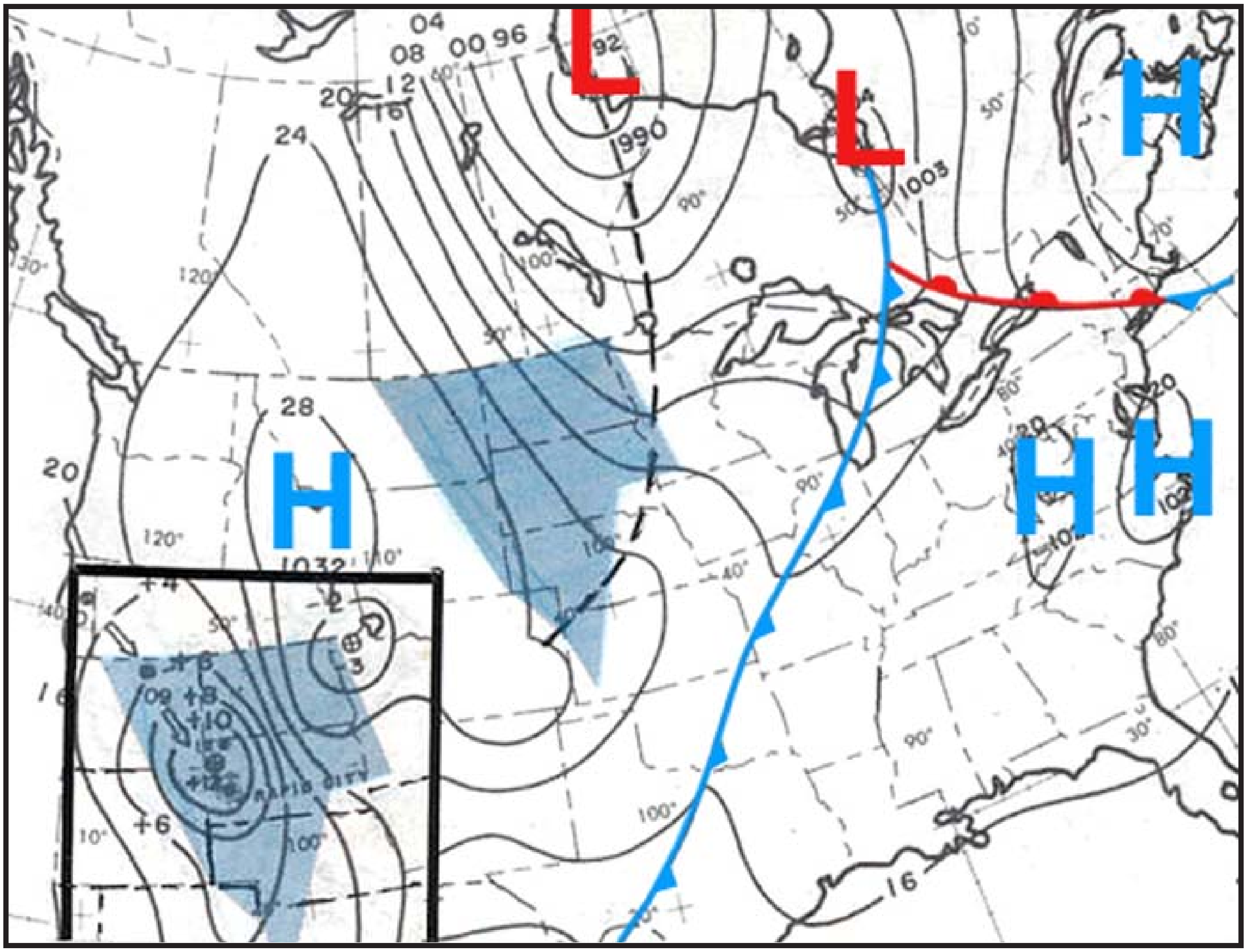

Figure 4-53. Northern Plains Box, Secondary Troughs Example. Inset: Pressure rises.

It was just shown that the Alberta Low regime often produces strong northwest winds over the northern and perhaps the central Great Plains. Another familiar synoptic event that produces strong west to northwest surface winds is shown in Figures 4-54 and 4-55. Colorado Low regimes, where deepening occurs over the central plain states, often initiates the northern Great Plains Box when deepening lows track northeastward. The 5400 thickness line (light blue) shows the thickness depth needed to produce snow.

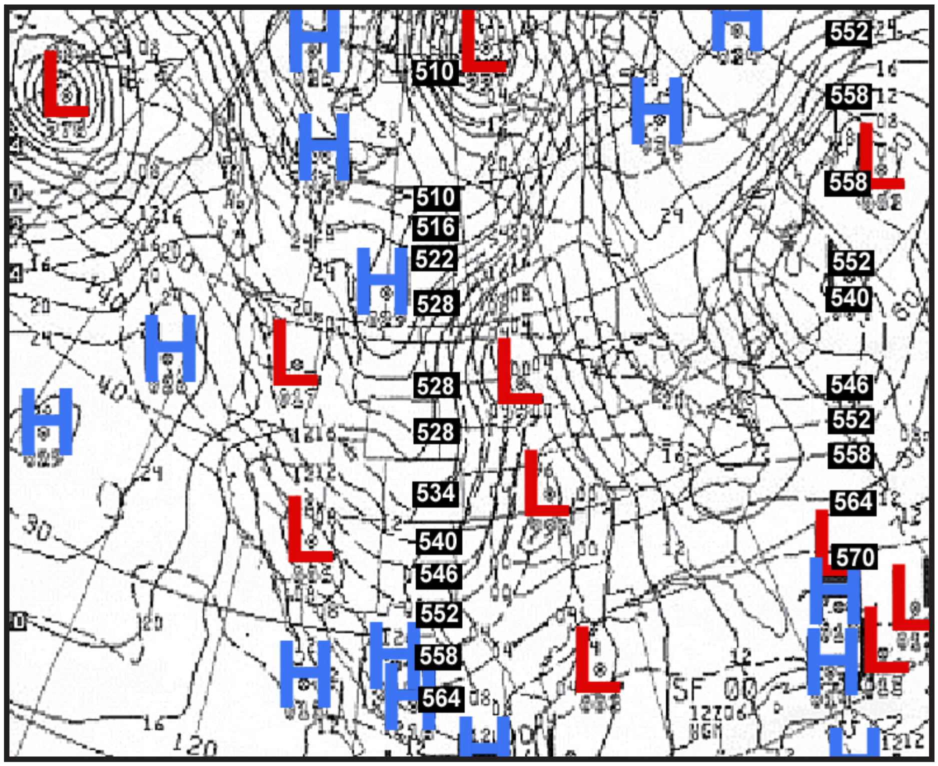

Figure 4-54. 00-Hour Mean Sea-Level Pressure/1000- to 500-mb Thickness, 1200Z/6 November 2000.

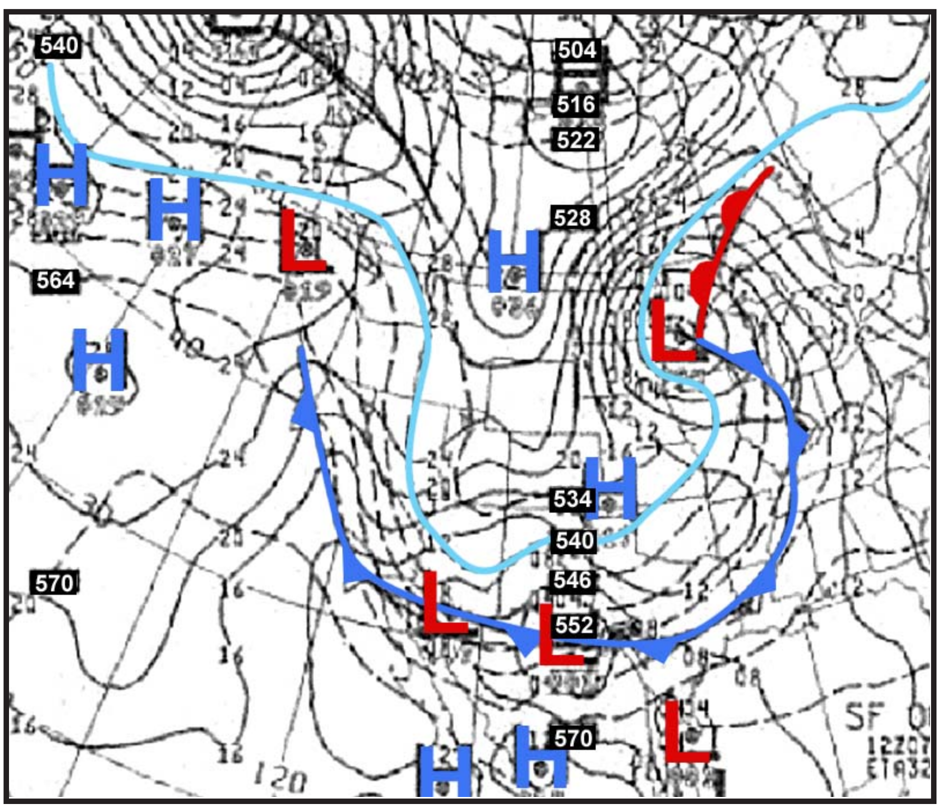

Figure 4-55. 00-Hour Mean Sea-Level Pressure/1000- to 500-mb Thickness, 1200Z/7 November 2000. Twenty-fours later than Figure 4-54.

Central Plains Box. Although this wind event occurs more often during the spring season, it will begin during late autumn and continue through the winter season when strong mP frontal systems move out of the Rocky Mountains. The surface pressure gradient tightens between the front and the receding polar ridge to the east. The southerly low-level jet becomes strong and is reflected on the surface by strong southerly winds (discussion on this wind regime and the low-level jet was presented earlier in this section). Figures 4-56 and 4-57 illustrate a typical pattern. The initial and forecast boundary layer wind and 850-mb charts are some of the tools for predicting the area of strong southerly winds. As shown in Figure 4-56, the lee-side trough is always located on the western side of the strong wind event.

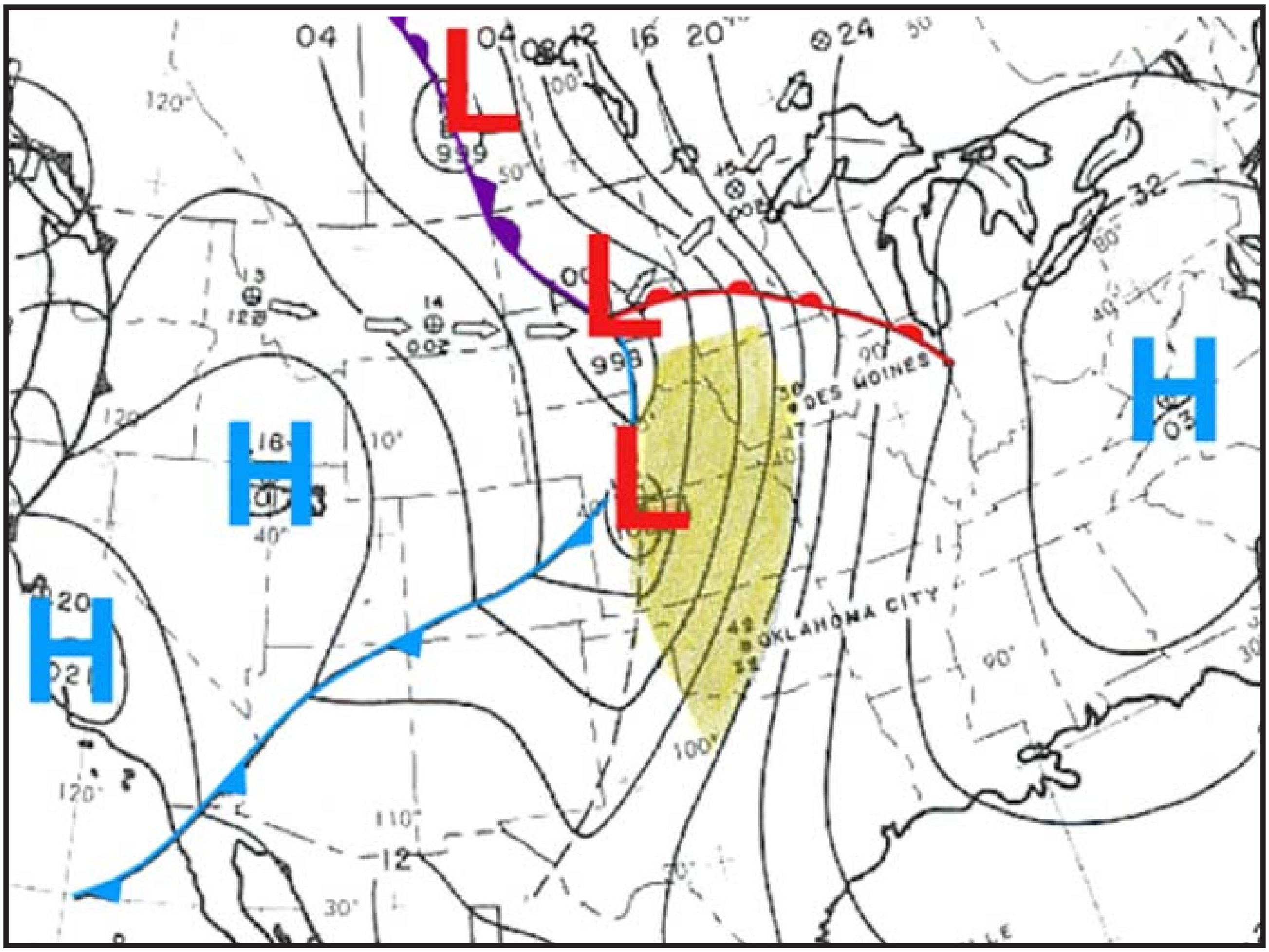

Figure 4-56. Central Plains Box.

The shaded area in the maximum wind chart (Figure 4-57), depicts the low-level jet. Surface winds greater than or equal to 35 knots are more likely over the Central Plains during the heating hours; the winds often lessen to 25-30 knots during the evening hours prior to cold frontal passage.

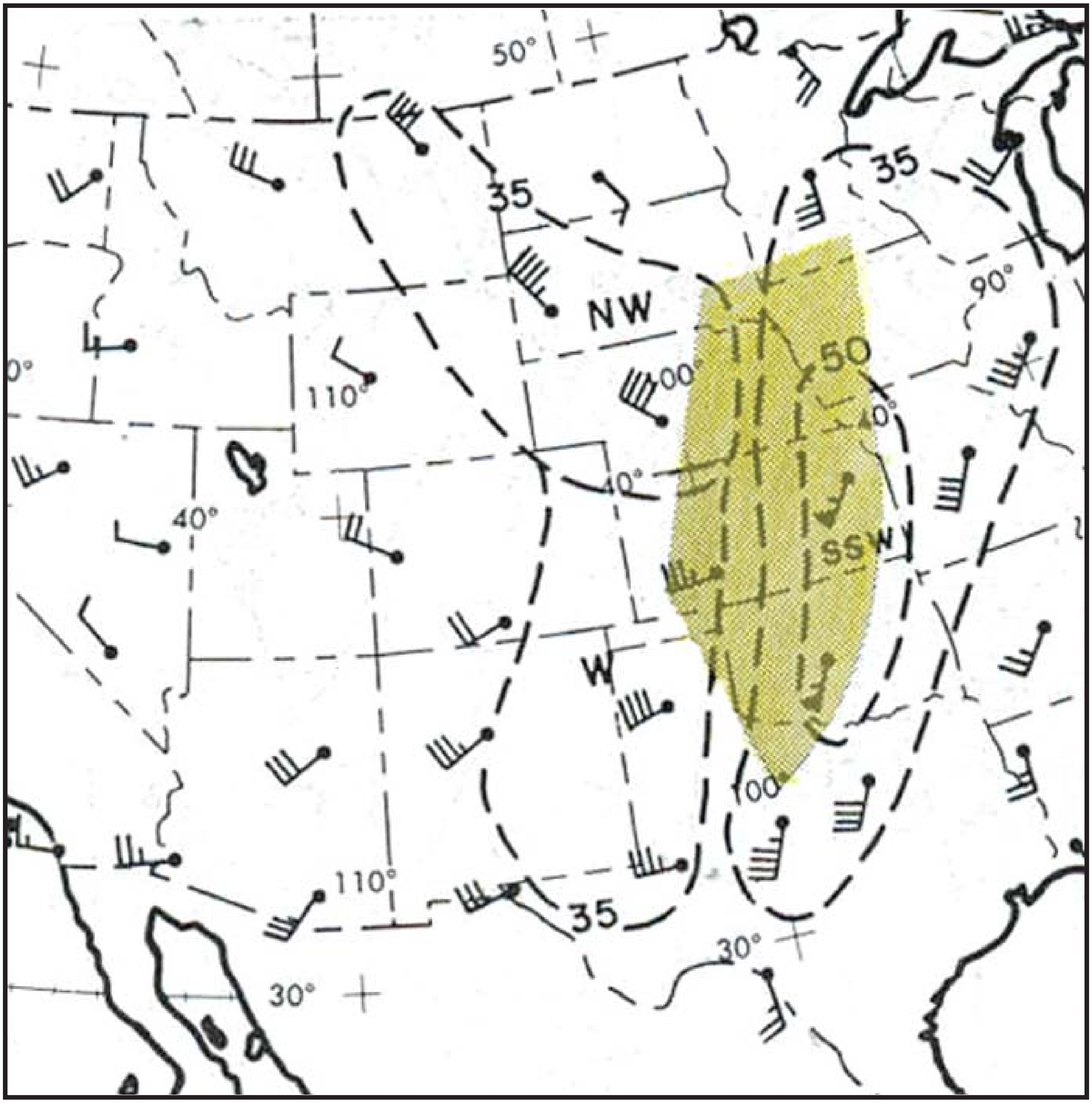

Figure 4-57. Central Plains Box Low-Level Maximum Winds.

FREEZING PRECIPITATION.

Synoptic-scale freezing precipitation events generally begin by late-November over the central and northern United States, as continental polar (cP) air masses become the dominant anticyclonic systems. Several freezing precipitation regimes that affect the central United States are described in detail in Winter Regimes and will not be shown in this Technical Note. One particular regime, however, will be presented. The event begins in early November across the northern Great Plains. The following information was extracted from AFWA /TN-98/001, *Freezing Precipitation.*

Northern Great Plains – Stationary Fronts. Continental polar air masses occasionally remain stationary over western and central Canada but continue to build. The upper flow is generally from the southwest. The southern boundary of the cP air mass is often observed from eastern Montana extending eastward across the Northern Plains as shown in Figure 4-58. Within the cold air behind the front, an extensive area of low stratus and fog (easterly low-level flow) often forms. Freezing drizzle occurs frequently in this stationary event, especially in the upslope flow over the western Dakotas and eastern Montana region. Sometimes an east-west trough is depicted on the surface chart rather than a stationary front. This pattern will end when a low moves out of the Rockies into the Central Plains, and the cold air and ridging moves rapidly southward behind the low.

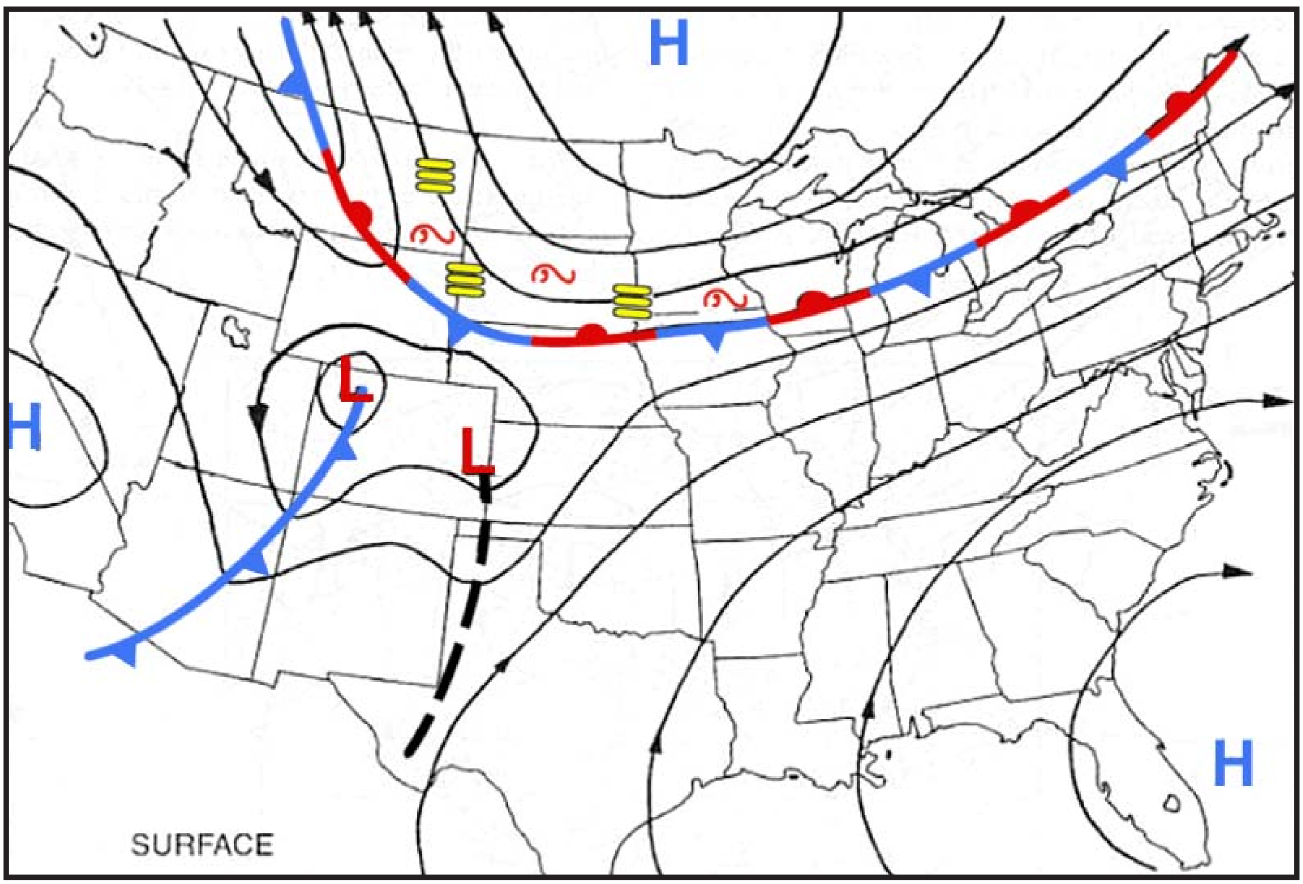

Figure 4-58. Northern Great Plains Stationary Fronts. Low stratus/fog and freezing drizzle occur within the cold air behind the polar front.

Figure 4-59 illustrates an example. A strong easterly upslope low-level flow extends across the Dakotas into Montana. Tighter thickness packing is noted north of the stationary cP front.

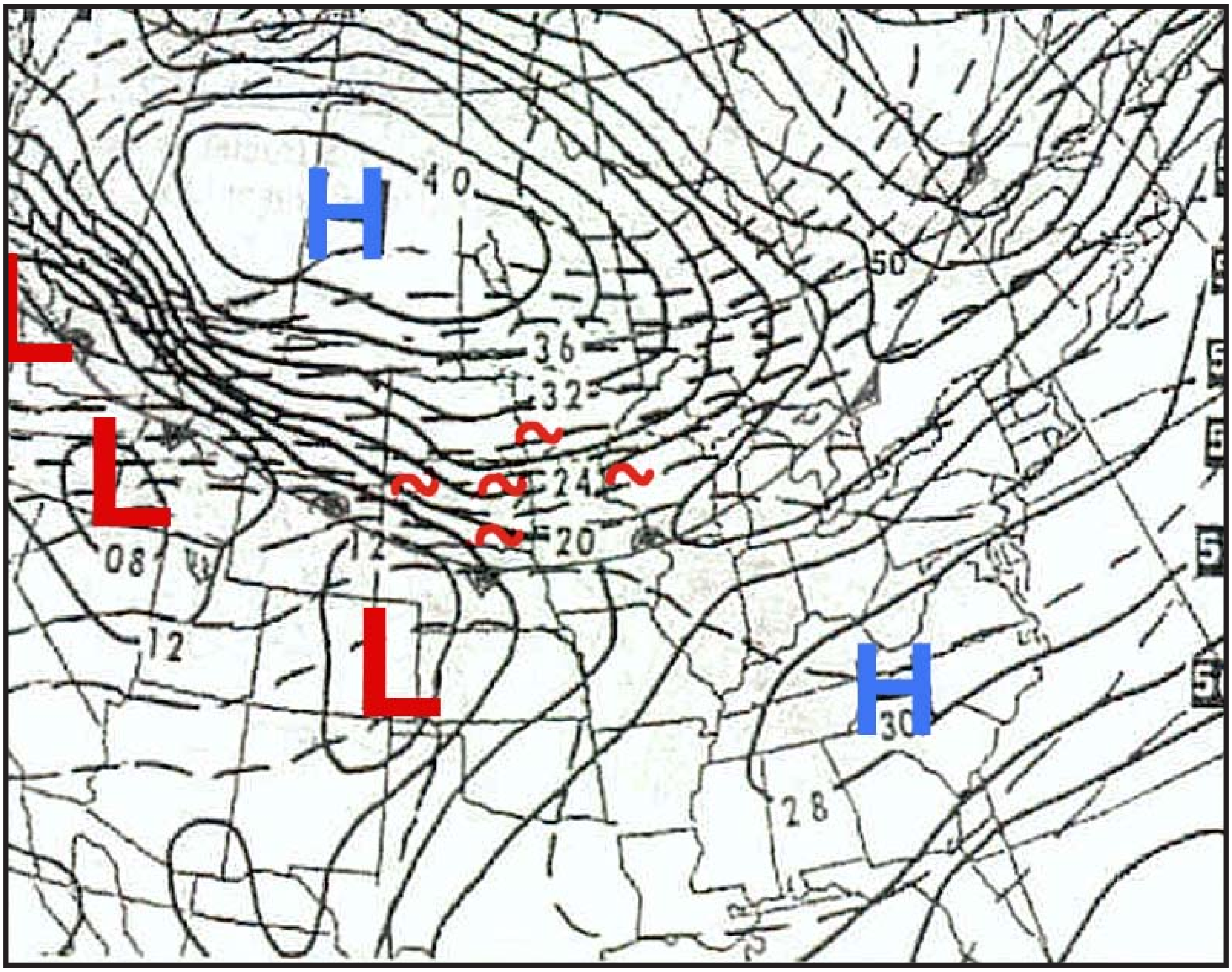

Figure 4-59. 00-Hour Mean Sea-Level Pressure/1000- to 500-mb Thickness, 1200Z/22 November 1993.

TROPICAL STORMS (GULF OF MEXICO)

The threat of tropical disturbances within the Gulf of Mexico that may affect Gulf Coast locations peaks during September and decreases to less than one occurrence per month by November. Any tropical disturbances in the Gulf of Mexico should always be suspect for potential development into a tropical storm or hurricane within a short period of time from September into November (Figure 4-60).

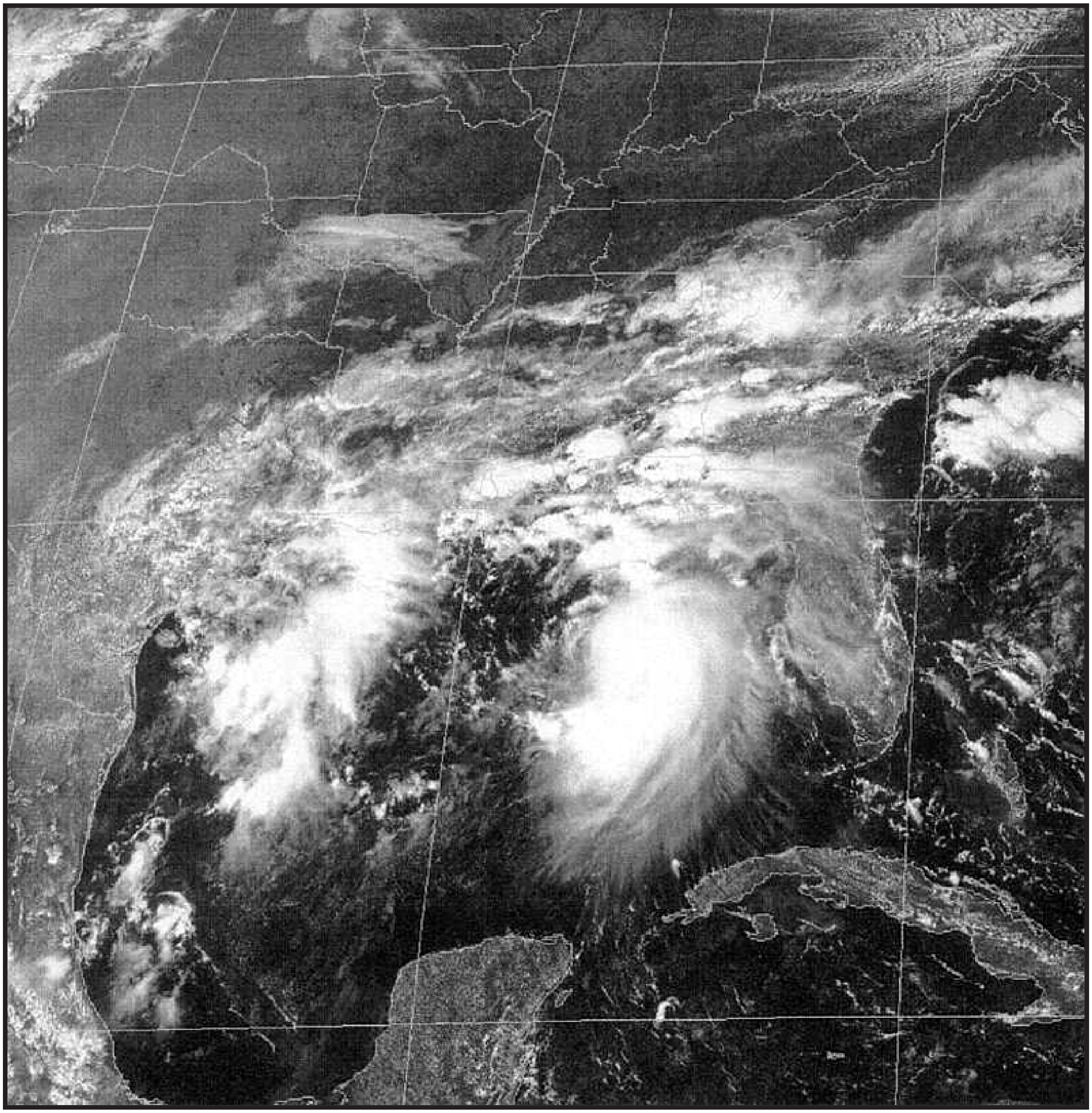

Figure 4-60. GOES East Visible, 1815Z/21 September 2000. This is the first day of now Tropical Storm Helene.

The year 2002 was an exceptional year for fall Gulf of Mexico tropical systems. In a two-week period from mid-September into early October, three storms wracked the northern Gulf Coast: Hanna, Isidore and Lili. In Figure 4-61a, Tropical Storm Hanna is heading towards the Florida Panhandle. Hanna's slow movement produced flooding across the Florida Panhandle and along the Alabama and Mississippi coastlines. Just over a week later,

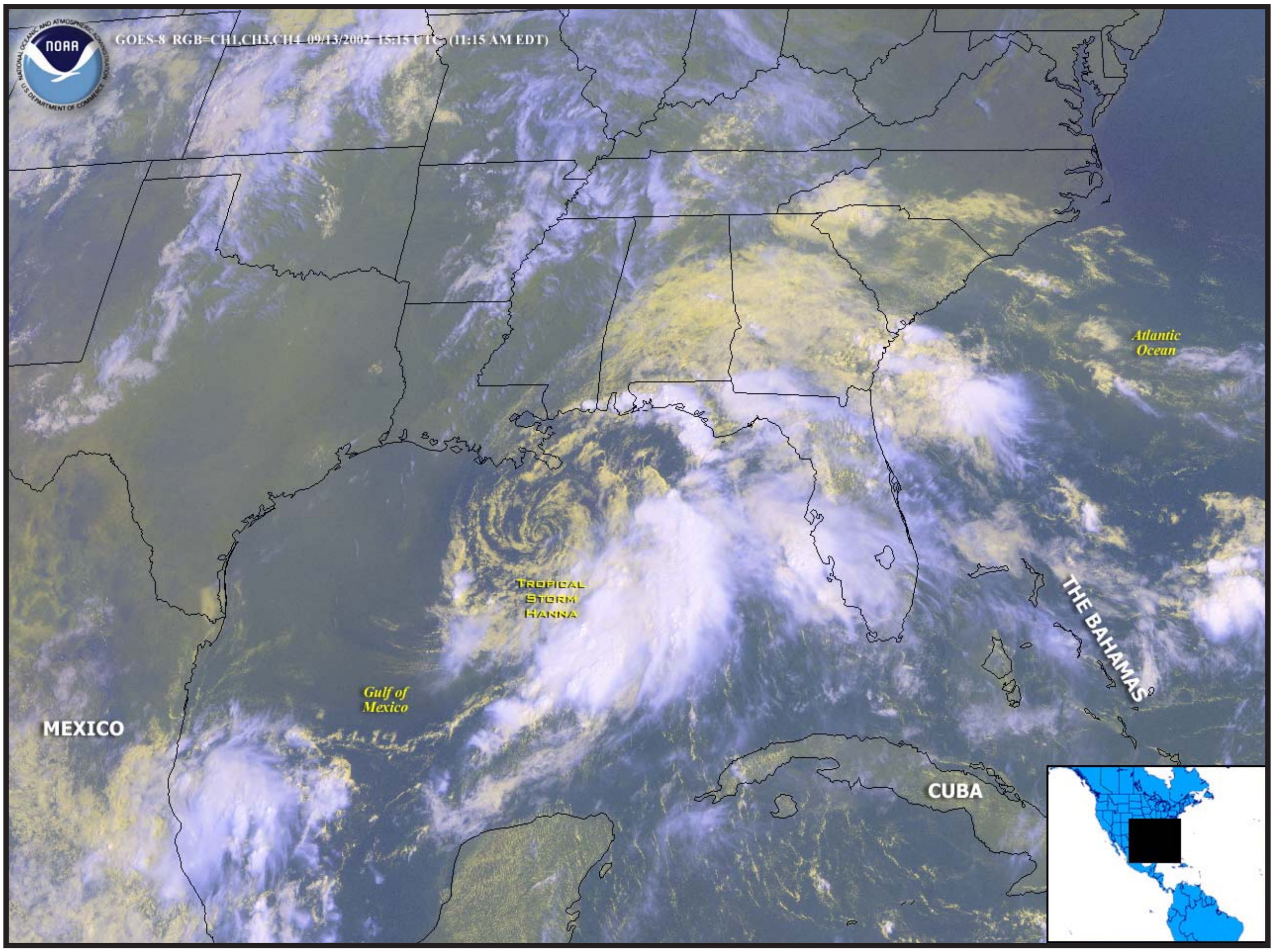

Figure 4-61a. Tropical Storm Hanna over the Gulf of Mexico. Hanna was moving north at 7 knots with maximum sustained winds estimated at 40 knots with gusts to 50 knots.

Tropical Storm Isidore (Figure 4-61b) made landfall east of New Orleans, Louisiana and drifted slowly north, producing more flooding across the northern Gulf Coast. The following week, yet another, more potent storm, Hurricane Lili, hit the Gulf Coast (Figure 4-62).

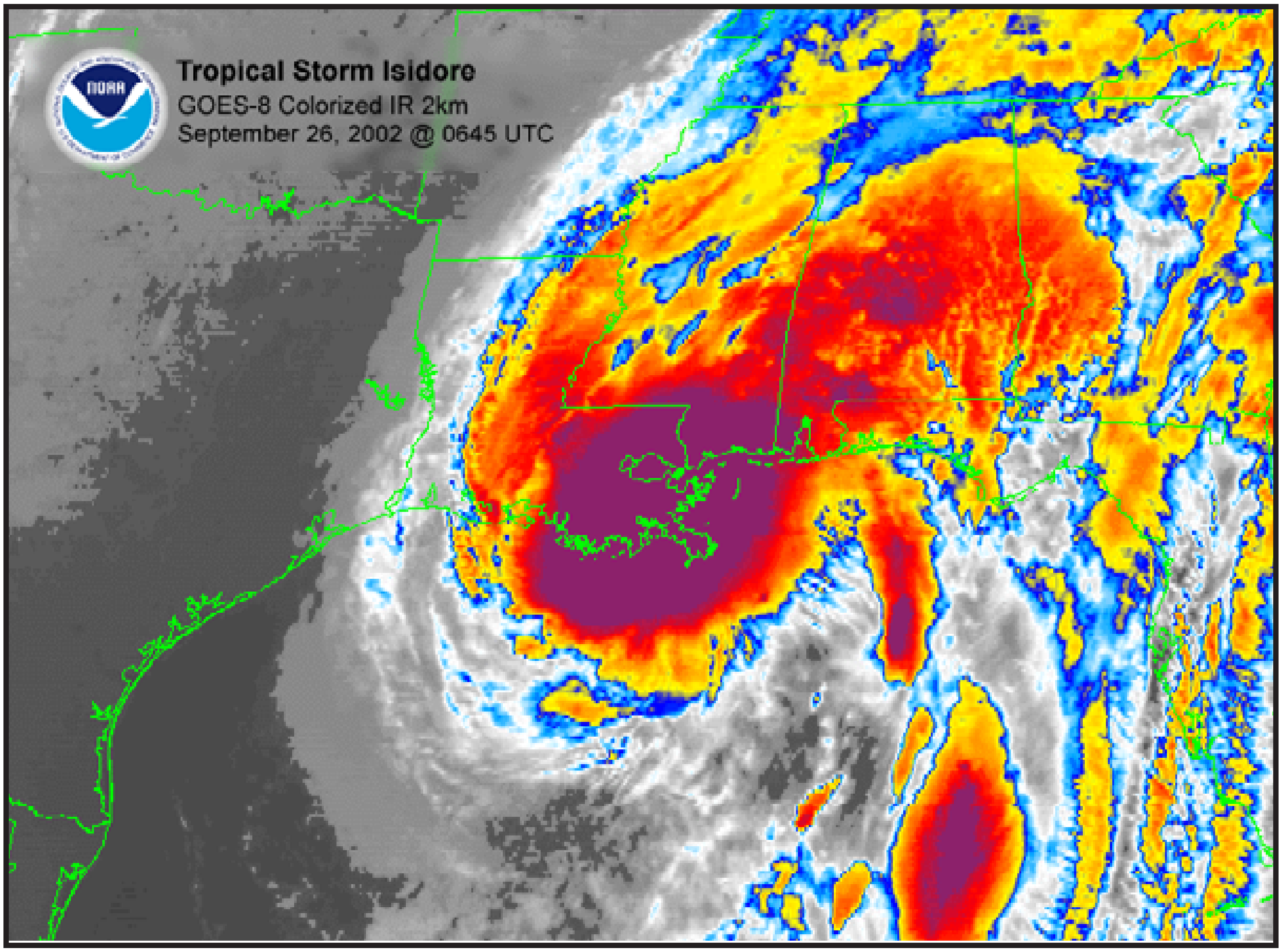

Figure 4-61b. GOES E Colorized IR, 0645Z/26 September 2002. Tropical Storm Isidore making landfall near New Orleans.

As seen in Figure 4-62, Lili had strengthened into a Saffir-Simpson category four storm and was still gaining strength. Notice the well-defined, tight eye and the surrounding overshooting tops in the eyewall. Some 21 hours later in Figure 4-63, Lili made landfall. However, it weakened into a category two storm that left meteorologists puzzled. The suspected culprit was an intrusion of dry air that moved in from the northwest out of Texas.

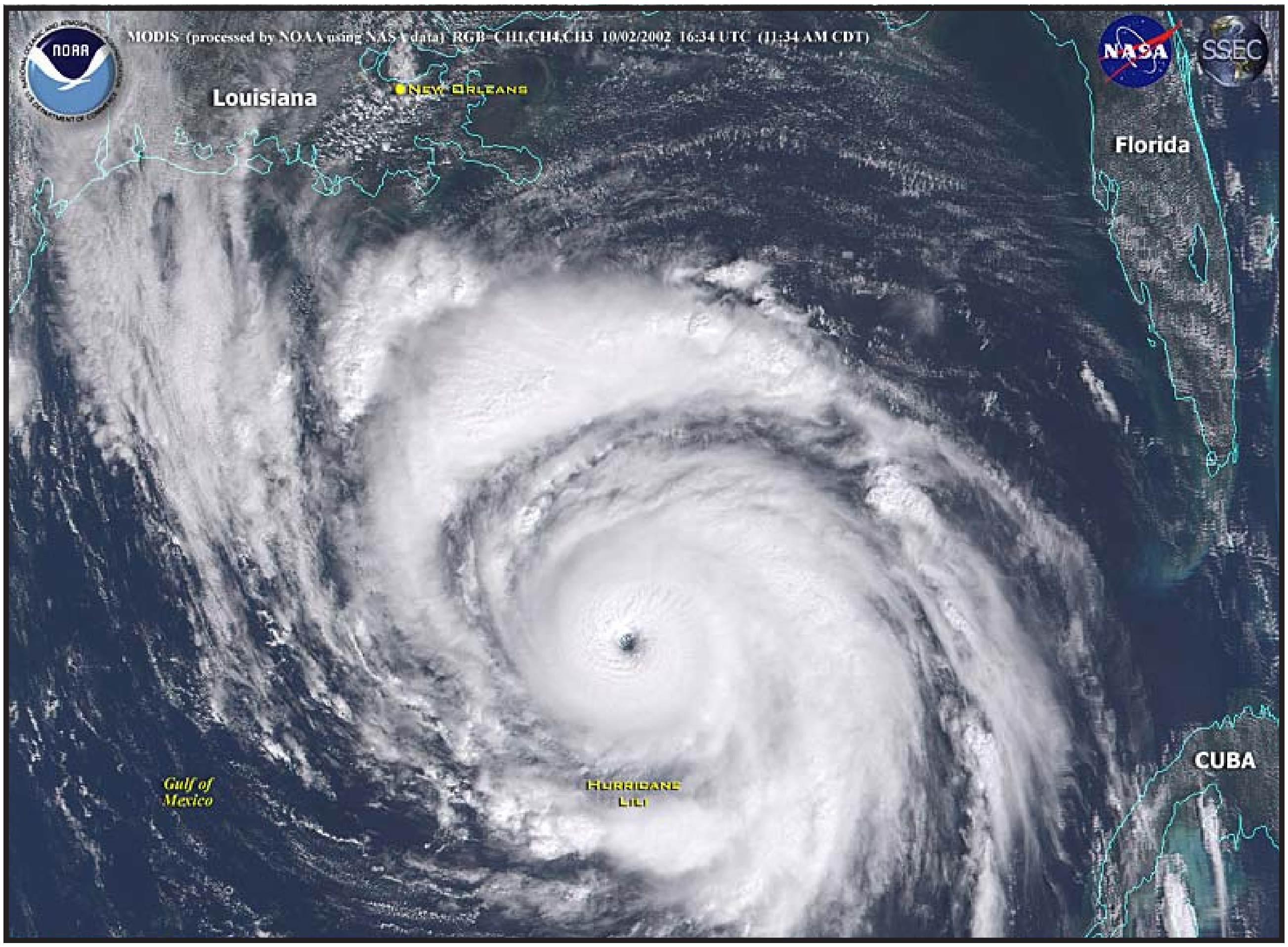

Figure 4-62. GOES East Visible, 1634Z/2 October 2002. Hurricane Lili, a category four storm, moving north-northwestward towards the Louisiana coast.

Figure 4-63. GOES East Visible, 1340Z/3 October 2002 Hurricane Lili making landfall over Louisiana a little over 21 hours later. The hurricane was approaching category five strength close to landfall before an unexpected dry-air intrusion weakened it to a category two storm as it made landfall.

THUNDERSTORMS

Summer's daily convection, associated with maximum insolation, low-level moisture and instability, continues to subside during autumn. An increase in mP and cP air masses across the northern and central Great Plains brings more stable and dryer environments, and along with decreasing insolation, reduces most convection generated by surface heating. Most thunderstorm occurrences during autumn are associated with frontal lifting, strong non-frontal convergence, upper level short waves and cold pockets. During early and mid-autumn, fronts often become stationary and aligned east-west over the southern Plains/Gulf of Mexico region. Consequently, the likelihood of more thunderstorm activity would occur along these stationary fronts where the air masses are moist (Gulf air) and unstable. Short waves, approaching from the southern Rockies, would enhance

thunderstorm development along these stationary fronts as shown in the following case example, Figures 4-64 and 4-65. In the satellite image, Figure 4-64, strong thunderstorms are noted across Texas and southern Oklahoma.

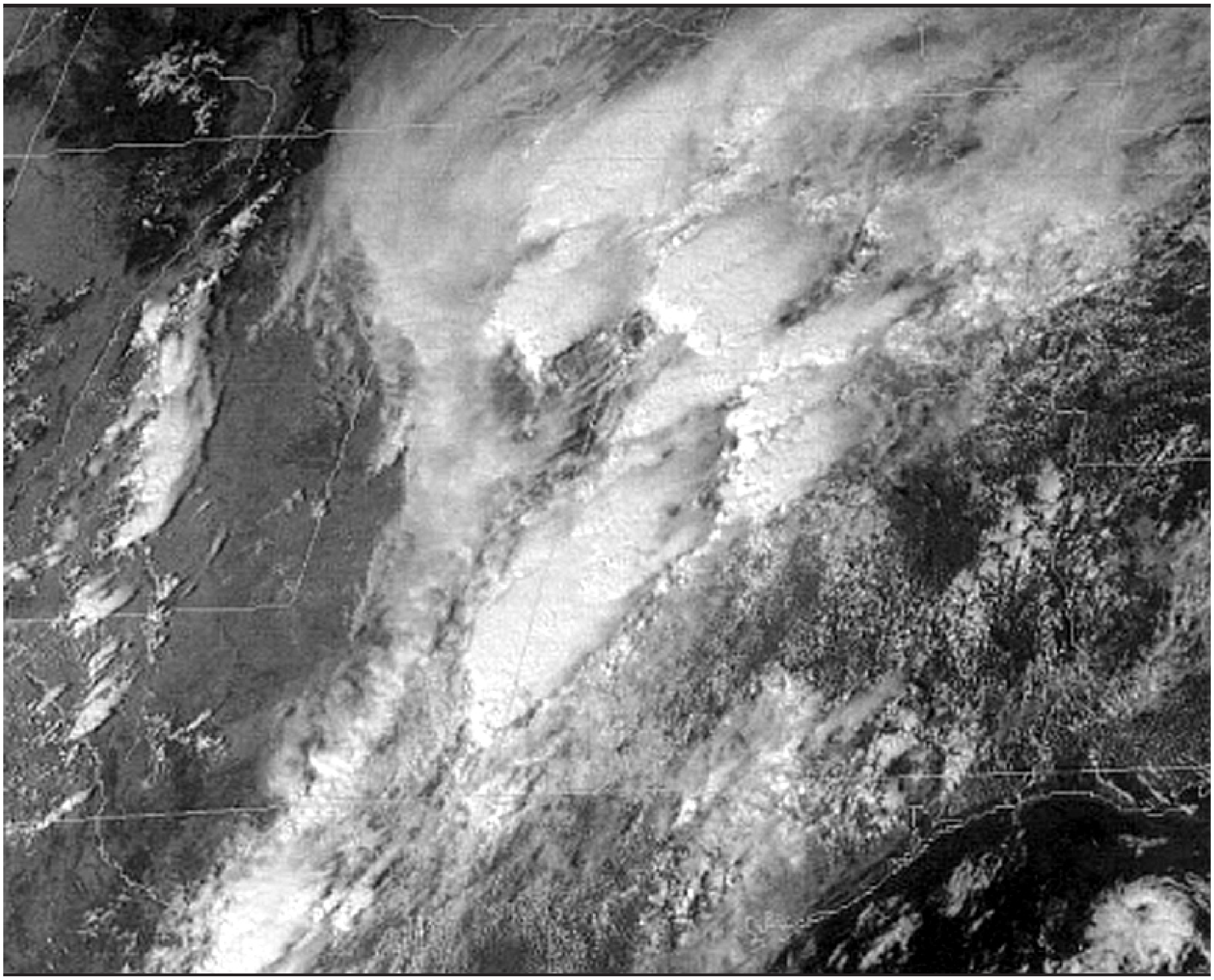

Figure 4-64. GOES East Visible, 1945Z/15 October 2000. Thunderstorms are observed over western Texas as shown.

Figure 4-65 shows the ETA 6-hour surface, 1000-500-mb thickness and 1,000-mb wind forecasts approximately two hours earlier than Figure 4-64. A maritime polar cold front has become stationary and is aligned east to west across northern Texas. A frontal wave/low developed over west Texas (Figure 4-65). A short wave impulse over Arizona and New Mexico shown in the inset will enhance frontal cyclogenesis and thunderstorms over western and central Texas. Figure 4-66 depicts another frontal thunderstorm event over the southern Great Plains.

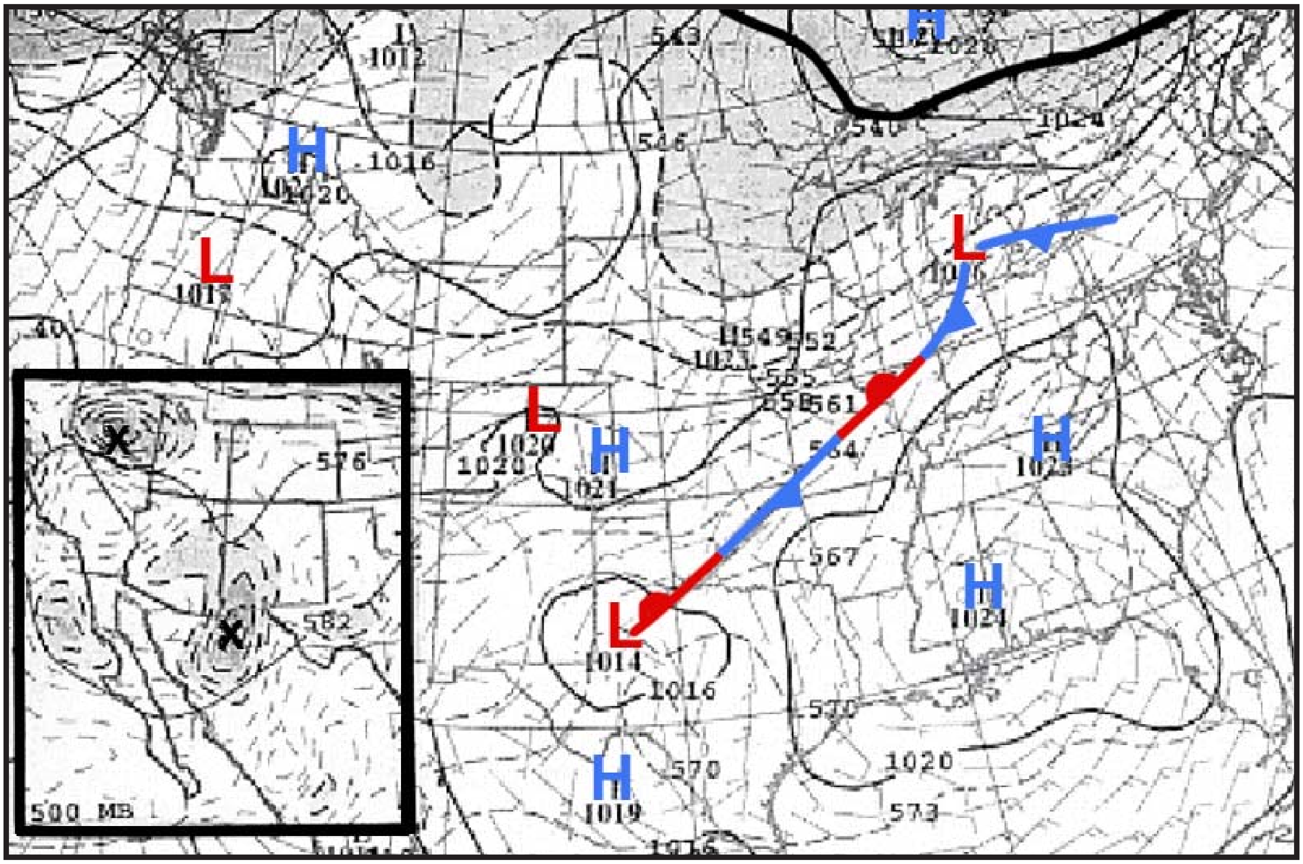

Figure 4-65. ETA 6-Hour Forecast Mean Sea-Level Pressure/1000- to 500-mb Thickness/1000-mb Winds, 1800Z/15 October 2000. Inset: ETA 500-mb Heights/Vorticity, 1800Z/15 October 2000.

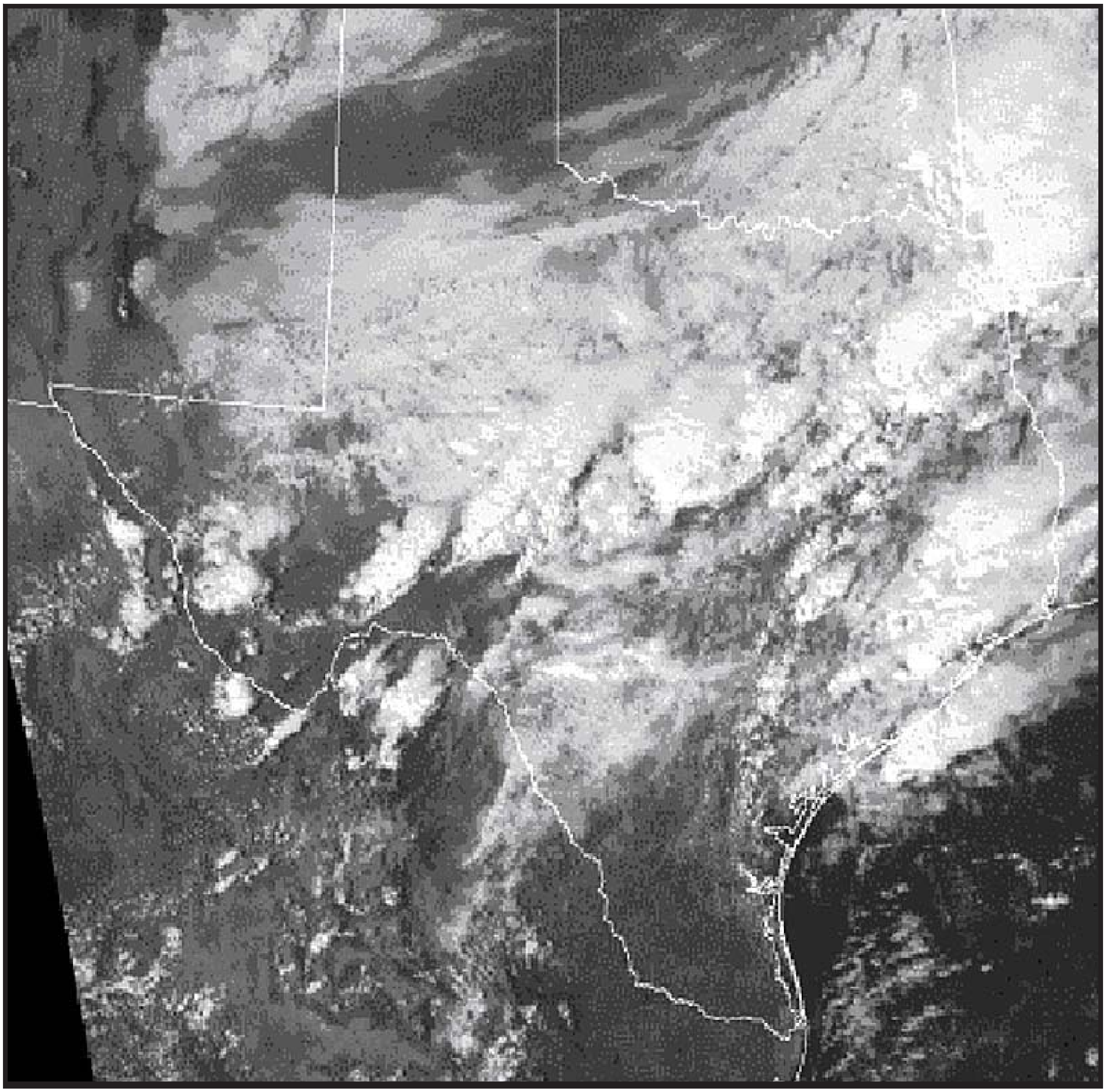

Figure 4-66. GOES E Visible, 1955Z/5 October 2001. Frontal thunderstorms extend across central Texas.

Pacific short waves moving into the western Great Plains often produce thunderstorms when associated fronts move into a moist, unstable air mass usually located over the central and eastern Great Plains (Figure 4-67). In Figure 4-67, a late afternoon image, a large mature comma system has moved out of the Rocky Mountains. Shadows help reveal thunderstorm clusters along the cold front from Kansas to Texas.

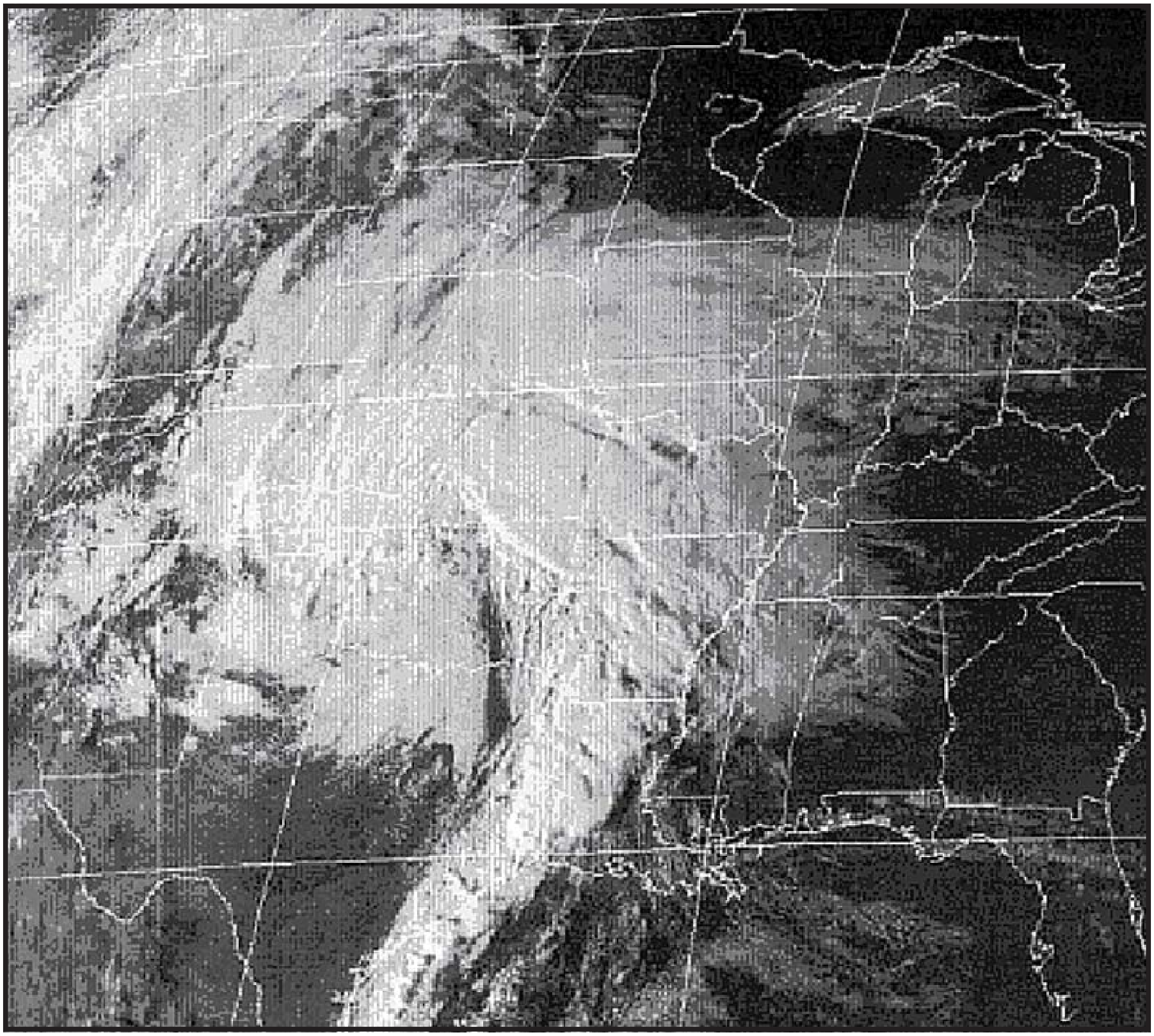

Figure 4-67. GOES East Visible, 2202Z/01 November 1998.

The reader should not become complacent about the absence of thunderstorms, especially severe thunderstorms, during the many quiet weather days of autumn. Severe frontal thunderstorms will occur throughout autumn and winter when the ingredients all come together. Let's look at a case study that occurred in the late 1980's (Figures 4-68 through 4-74). No model data was saved for this event. At the start of this event, Figure 4-68, the surface analysis shows that a low has organized over southeastern Colorado (the Colorado Low Regime). The **X** shown over north central New Mexico is the position of the 1200Z height-fall center. Although another low is shown over eastern Nebraska in Figure 4-68, the primary low will be the Colorado low and relates to the vorticity and height fall centers.

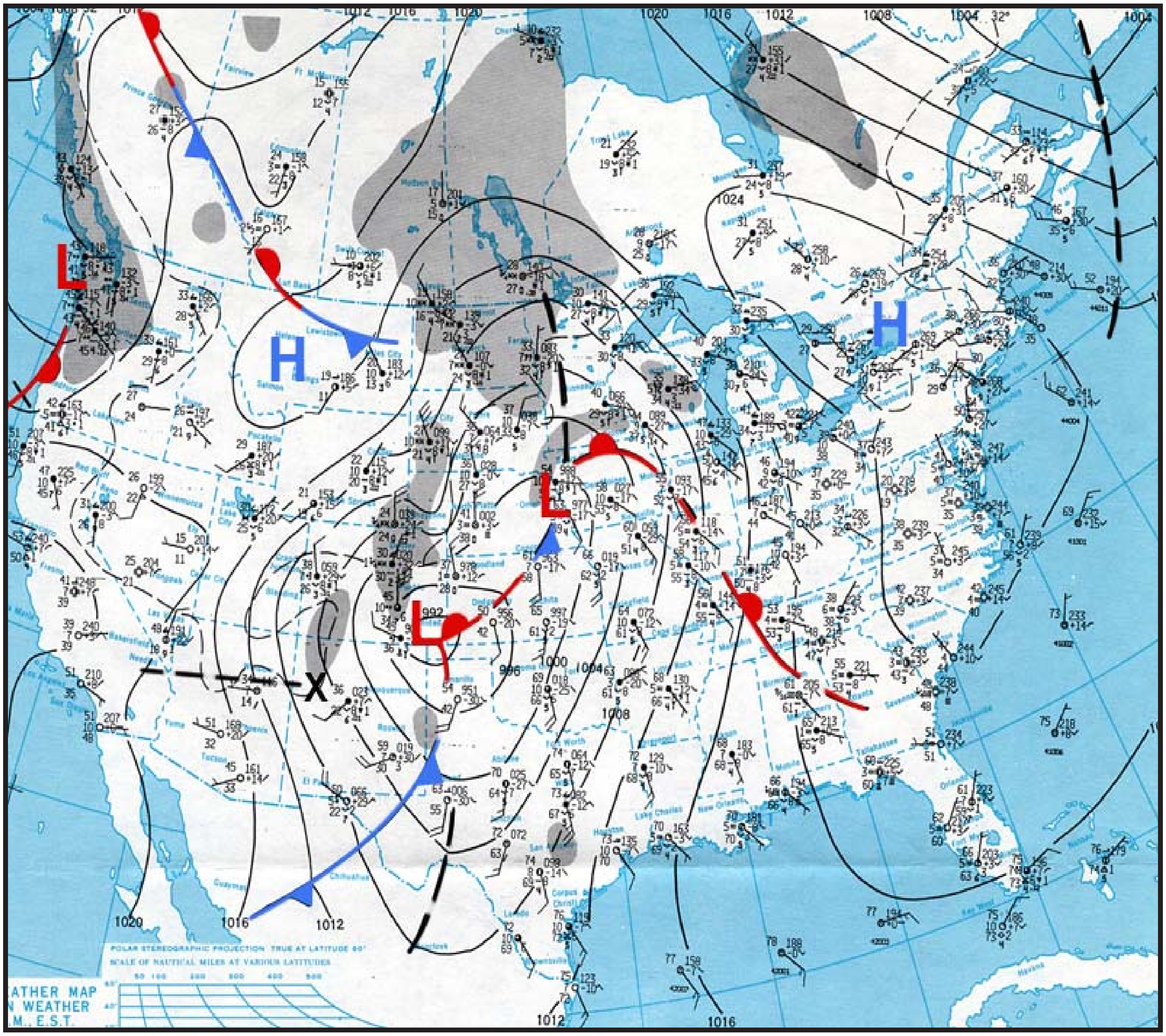

Figure 4-68. Surface Analysis, 1200Z/15 November 1988

Figure 4-69 depicts the related 500-mb analysis. A split flow short wave with a developing low is shown over Colorado and New Mexico. A height fall of –25 over the Albuquerque area indicates a strong system. Jet stream maximum speeds are 80 to 90 knots at the base of the trough.

The satellite image shown in Figure 4-70 (approximately seven hours later from Figures 4-68 and 4-69) reveals the comma system. The center of rotation can be seen over southwestern Kansas. Severe thunderstorms are occurring along the cold front from Missouri to northeastern Texas as

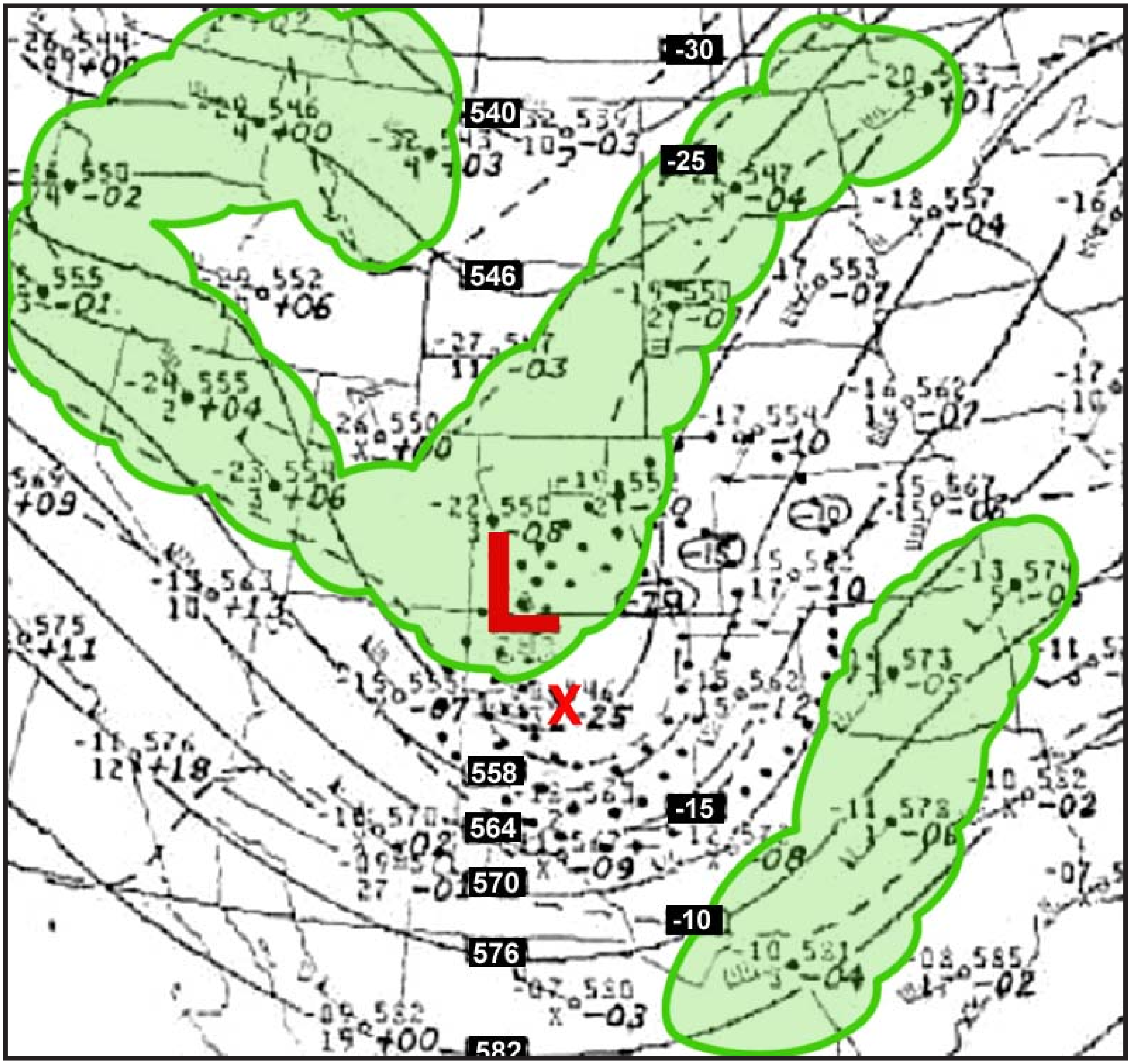

Figure 4-69. 500-mb Analysis, 1200Z/15 November 1988

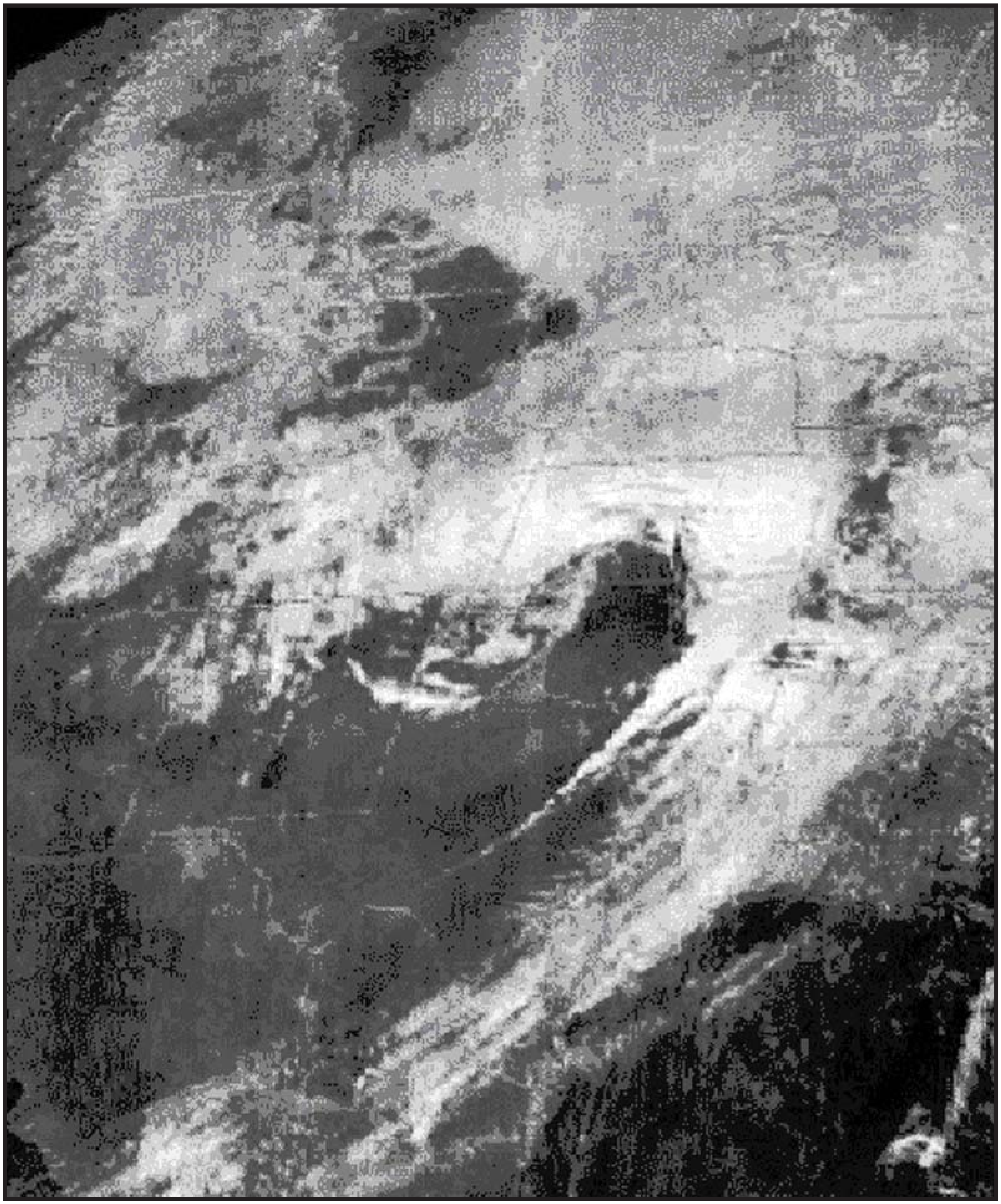

Figure 4-70. GOES East Visible, 1858Z/15 November 1988

depicted in Figure 4-71 (severe weather reports received at AFWA's Severe Weather Unit). Figure 4-72 depicts the severe thunderstorm symbols shown in Figure 4-71.

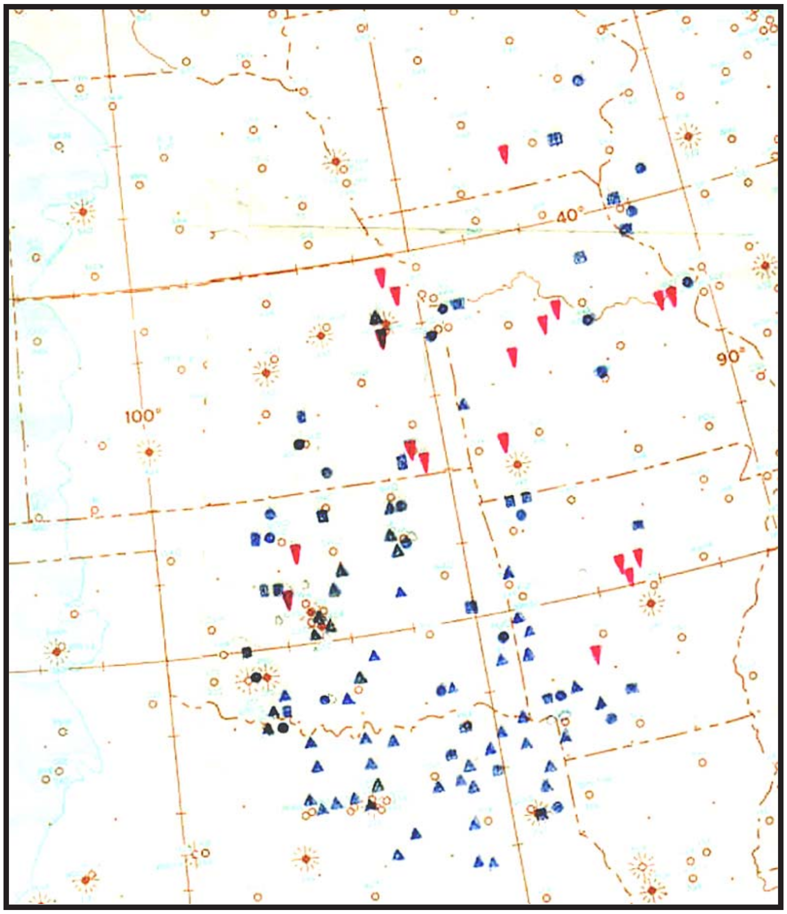

Figure 4-71. Severe Thunderstorm Reports, 1500Z – 2100Z/15 November 1988

Severe Thunderstorm Symbols

▲ **Hail ≥ 3/4"**
■ **Wing Damage**
● **Convective Gusts ≥ 50 Knots**
▼ **Tornado**

Figure 4-72. Severe Thunderstorm Symbols.

Figures 4-73 and 4-74 show the deep Great Plains storm system 24 hours later. The low bottomed out over the Texas Panhandle area and deepened rapidly as shown by the dashed track in Figure 4-74.

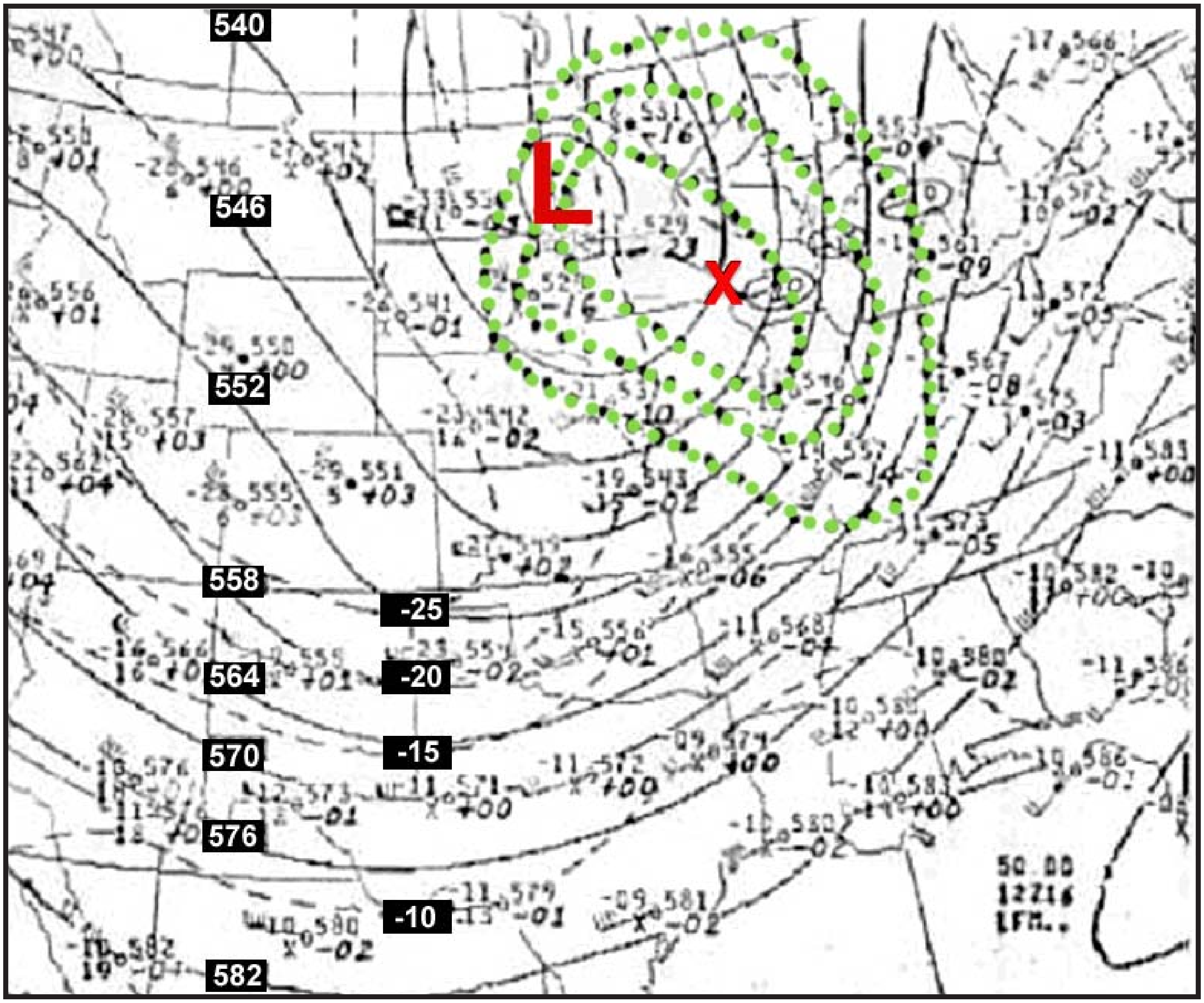

Figure 4-73. 500-mb Analysis, 1200Z/16 November 1988

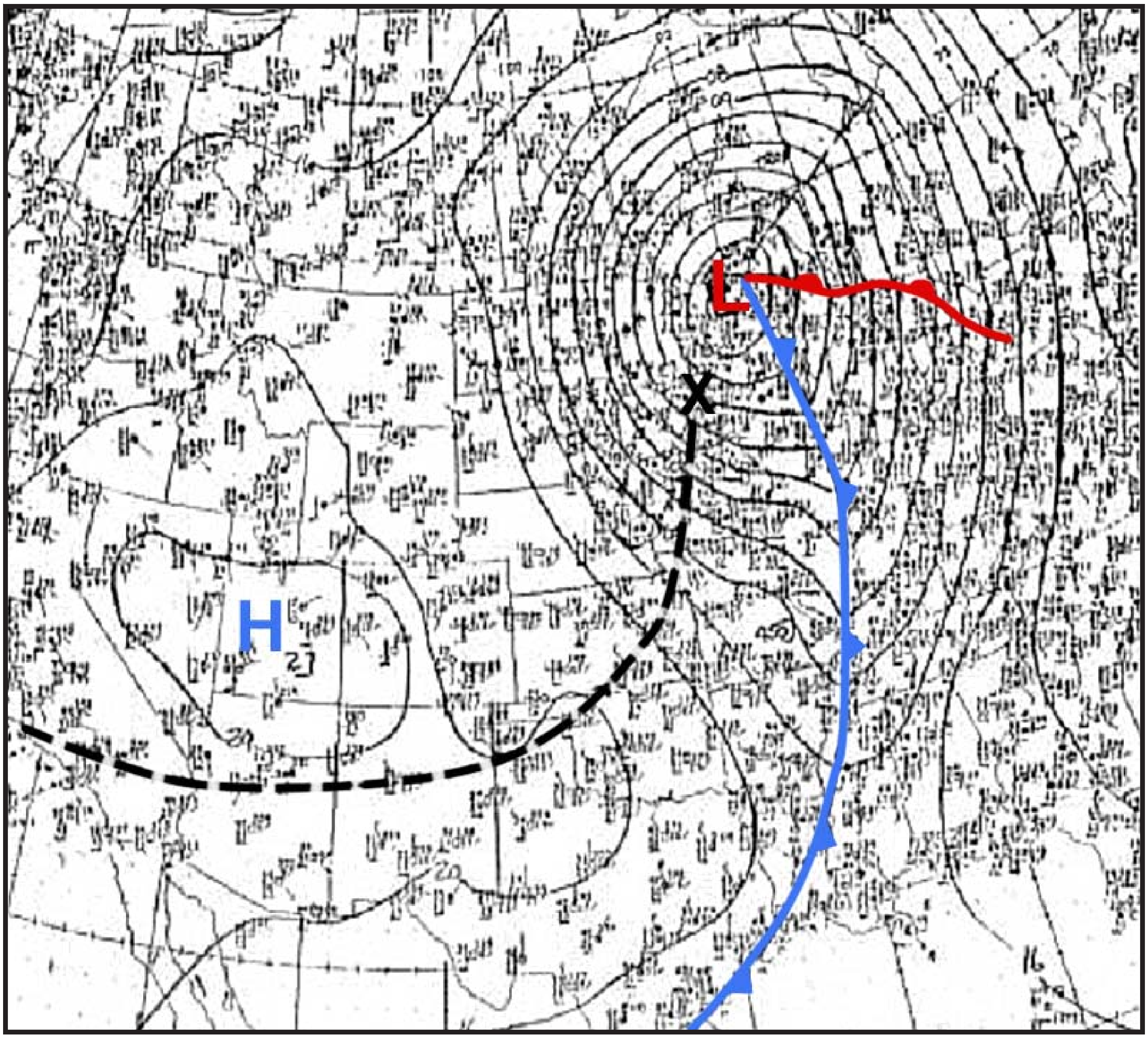

Figure 4-74. Surface Analysis, 1200Z/16 November 1988

A summary of severe thunderstorm events during September and October for the past four years that were reported across the United States by the public, spotters and law enforcement agencies are depicted in Figures 4-75 through 4-82 (these reports were received in AFWA's Severe Weather Unit). The intent in showing these events is the decrease in convection and severe thunderstorms from September to October and how severe activity changes from year to year (see Figure 4-72 for Symbology for Figures 4-75 and 4-76).

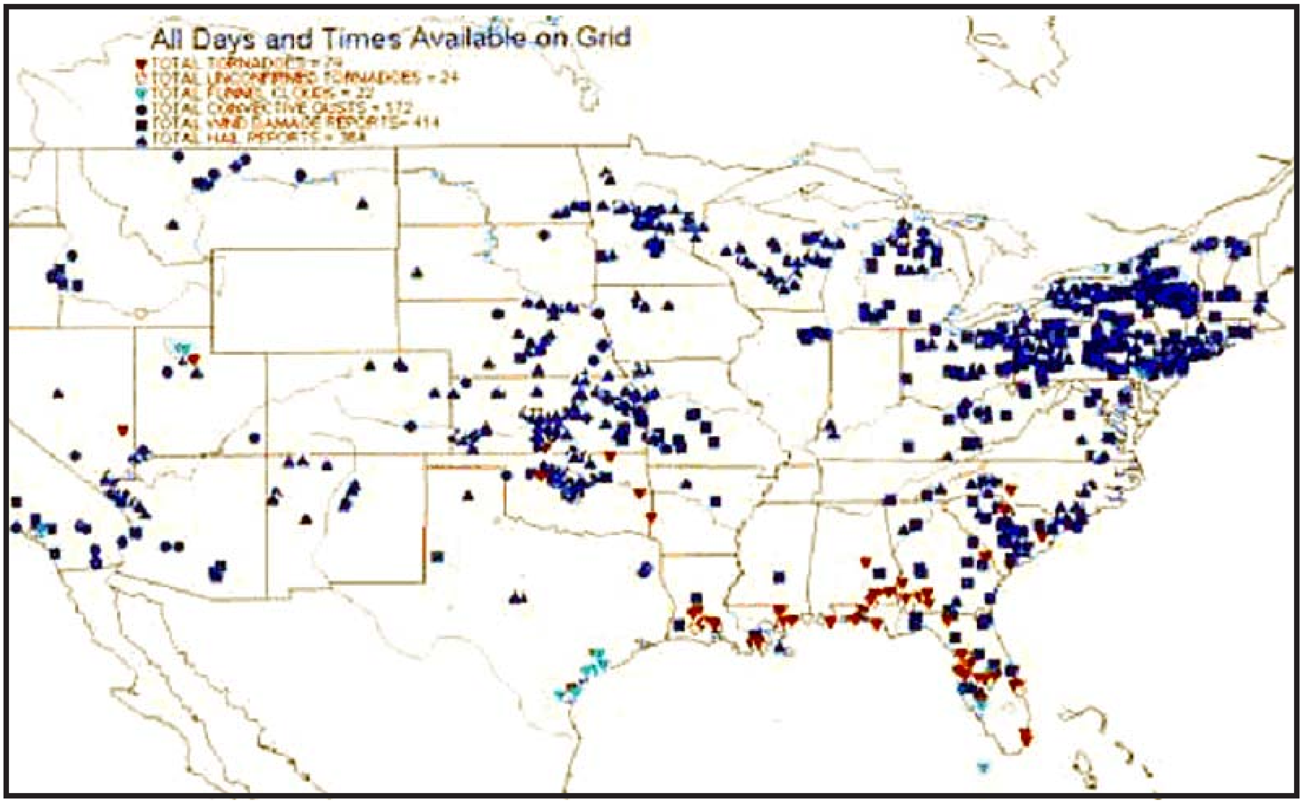

Figure 4-75. Tornado and Severe Thunderstorm Reports, September 1998.

In Figure 4-76, no severe thunderstorms were reported over the eastern United States during October – quite a change from September (Figure 4-75). Severe thunderstorm activity over the central and southern Great Plains continued to be active in October as shown in Figure 4-76.

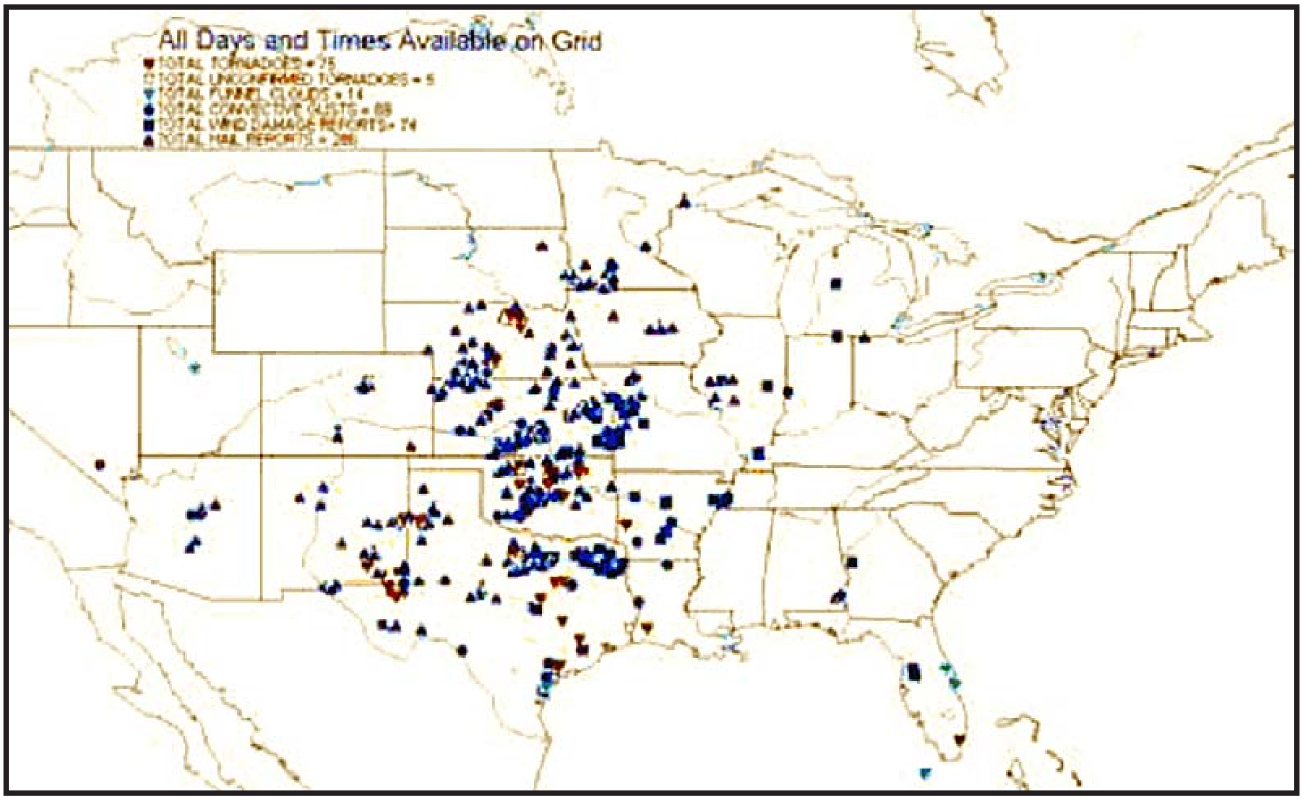

Figure 4-76. Tornado and Severe Thunderstorm Reports, October 1998.

September and October 1999 severe thunderstorm events are respectively shown in Figures 4-77 and 4-78. (Note: The symbology and colors for the severe weather criteria as shown in the symbology in Figures 4-77 through 4-82 were changed from the colors shown in Figures 4-75 and 4-76).

In Figure 4-78, tornado and severe thunderstorm occurrences over the Great Plains decrease significantly as compared to October 1998 (Figure 4-76). The severe thunderstorm reports shown over the Great Lakes and western Pennsylvania and New York all **occurred on one day** (13 October).

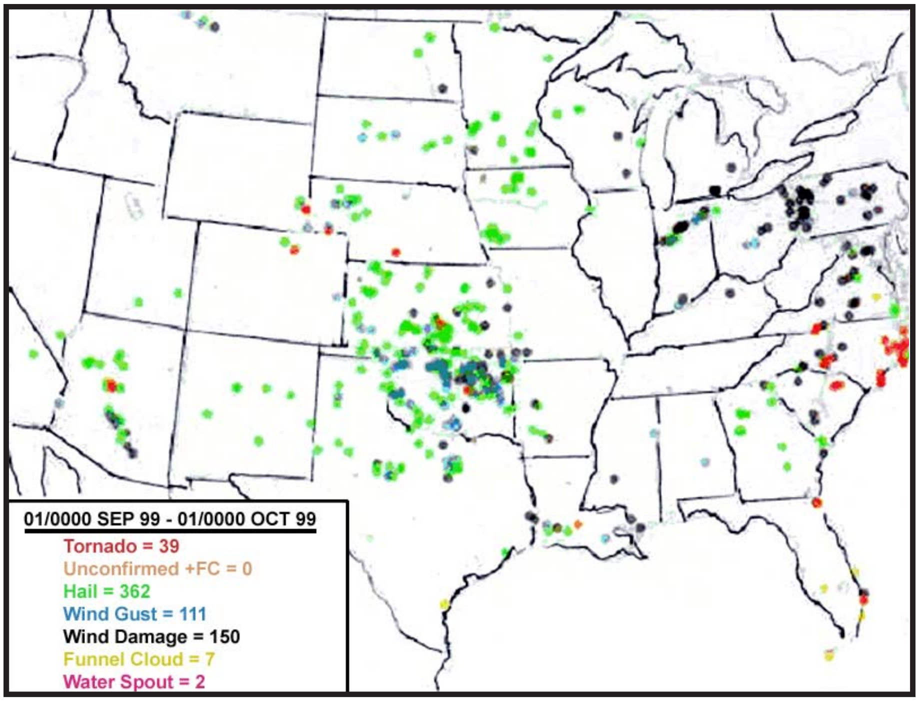

Figure 4-77. Tornado and Severe Thunderstorm Reports, September 1999.

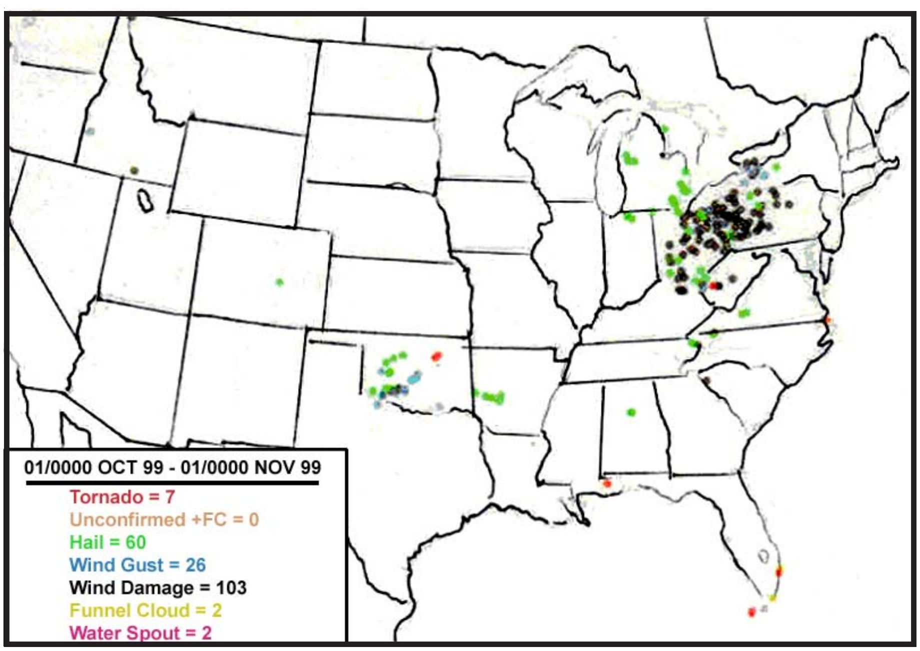

Figure 4-78. Tornado and Severe Thunderstorm Reports, October 1999.

Figures 4-79 and 4-80 respectively depict September and October 2000 severe thunderstorm occurrences. In Figure 4-80, the October severe reports shown over northern Ohio to the East Coast **occurred on one day** (4 October) otherwise most of the eastern United States experienced a quiet non-severe month. The central region of the United States continues to be active – nearly all reports received occurred between 23 and 31 October 2000 as shown in Figure 4-80

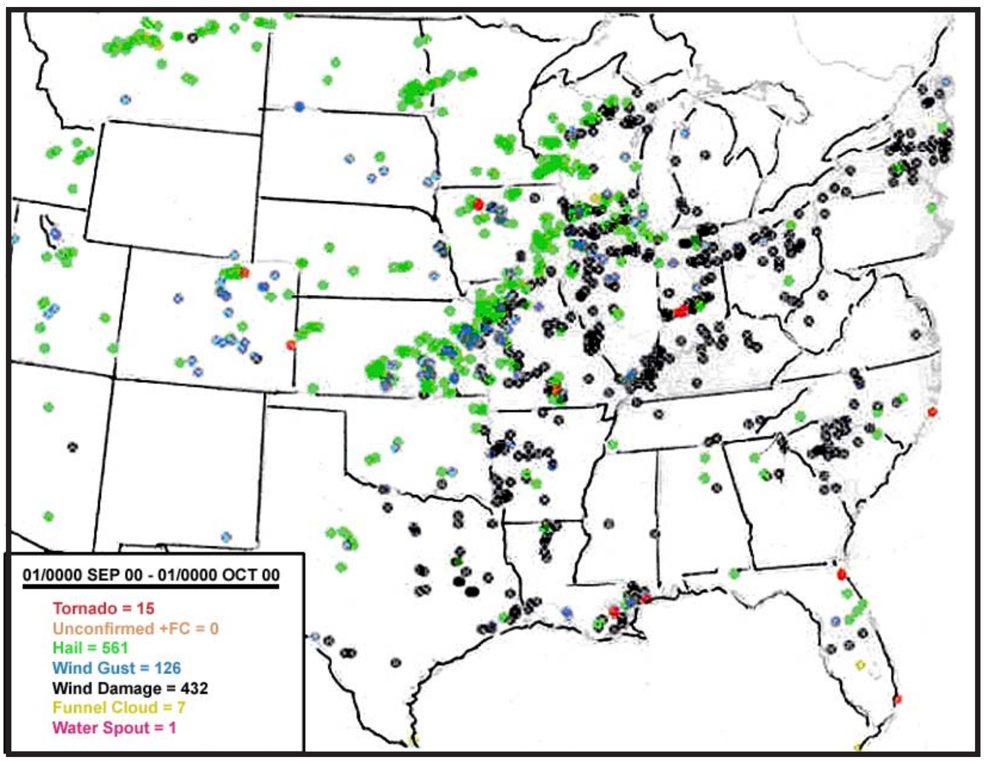

Figure 4-79. Tornado and Severe Thunderstorm Reports, September 2000.

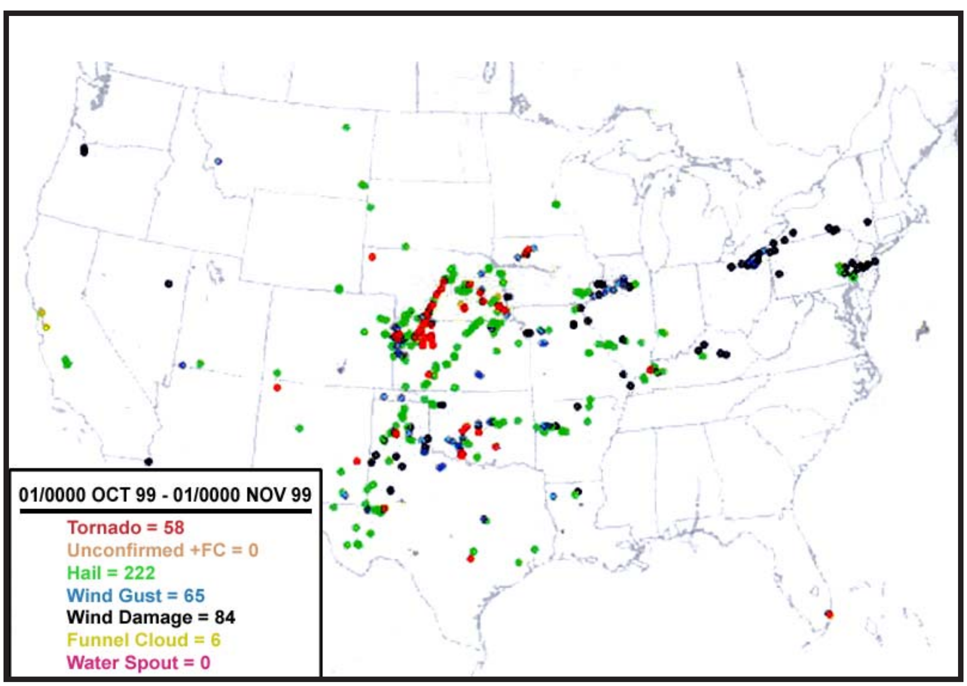

Figure 4-80. Tornado and Severe Thunderstorm Reports, October 2000.

Figures 4-81 and 4-82 depict tornado and severe thunderstorm activity during September and October 2001. October 2001 was not an average severe thunderstorm month as compared with the three previous years shown in earlier in Figures 4-76, 4-78 and 4-80. One storm, which occurred on October 24, accounted for 562 of the 1,209 reports received (see Figures 4-6 through 4-14).

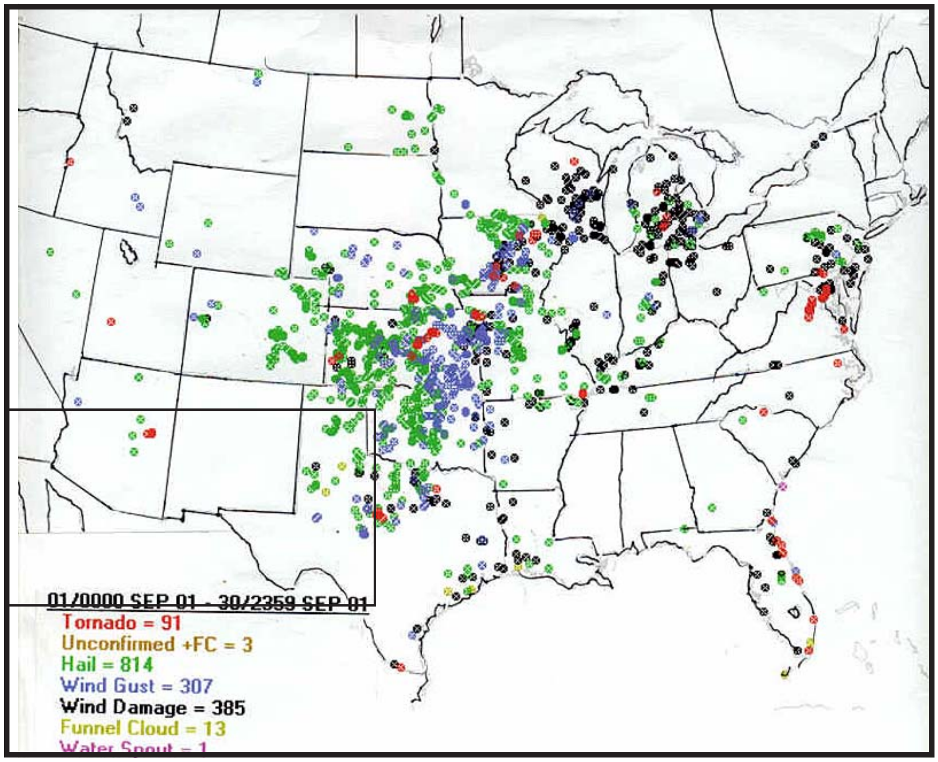

Figure 4-81. Tornado and Severe Thunderstorm Reports, September 2001

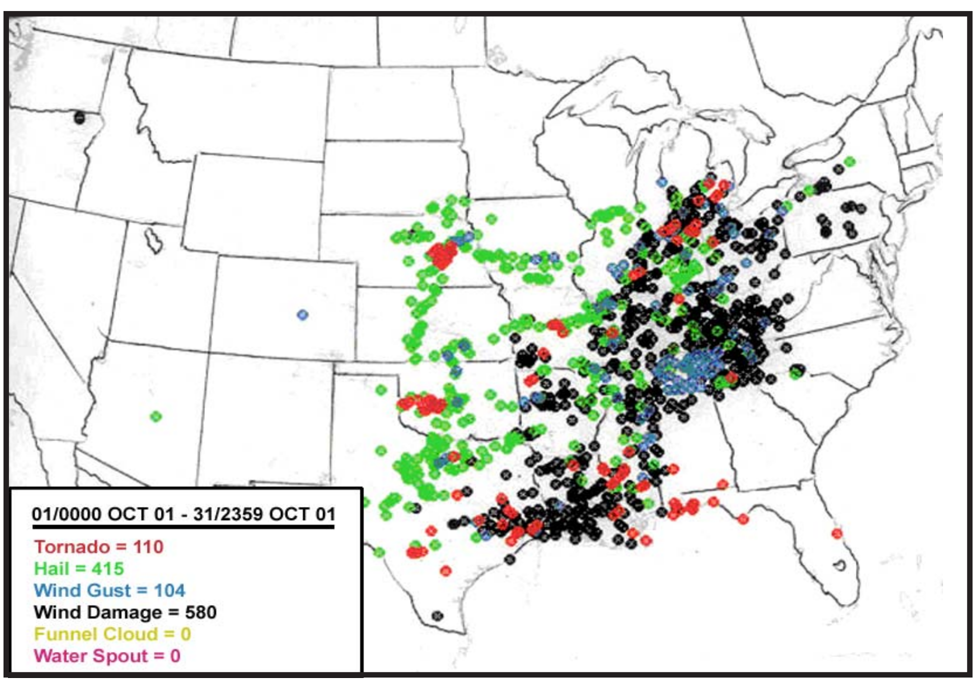

Figure 4-82. Tornado and Severe Thunderstorm Reports, October 2001.

Chapter 5

EASTERN UNITED STATES

SYNOPTIC REGIMES

Synoptic regimes pertaining to short and long waves, and polar and subtropical jet stream systems were discussed in Chapter 2 and Chapter 3. During most of autumn, short wave systems are observed often across the United States; long wave regimes begin by mid-November. Note: Little data for autumn was collected and saved over the years for the eastern United States. Therefore, I have relied on the Daily Weather Map series for material.

Towards late September, the Great Lakes and northeastern United States regions experience an increase in low-pressure systems as the polar jet and associated storm systems shift southward (Figure 5-1). The increase in passages of low-pressure systems over the Great Lakes region during autumn brings more cloudiness and precipitation (Figures 5-2 and 5-3). Measurable snowfall begins over the upper Great Lakes and Maine by mid-October.

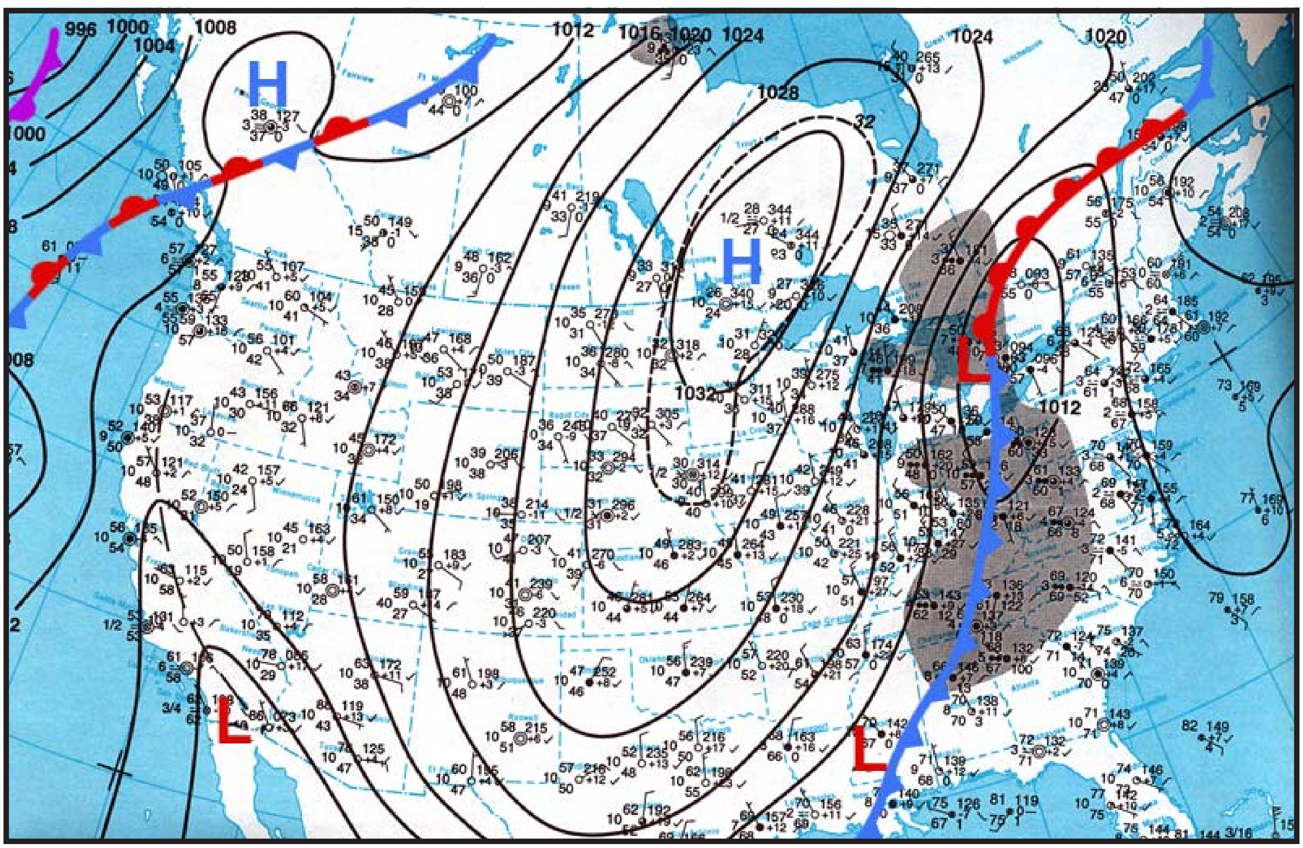

Figure 5-1. Surface Analysis, 1200Z/24 September 2001

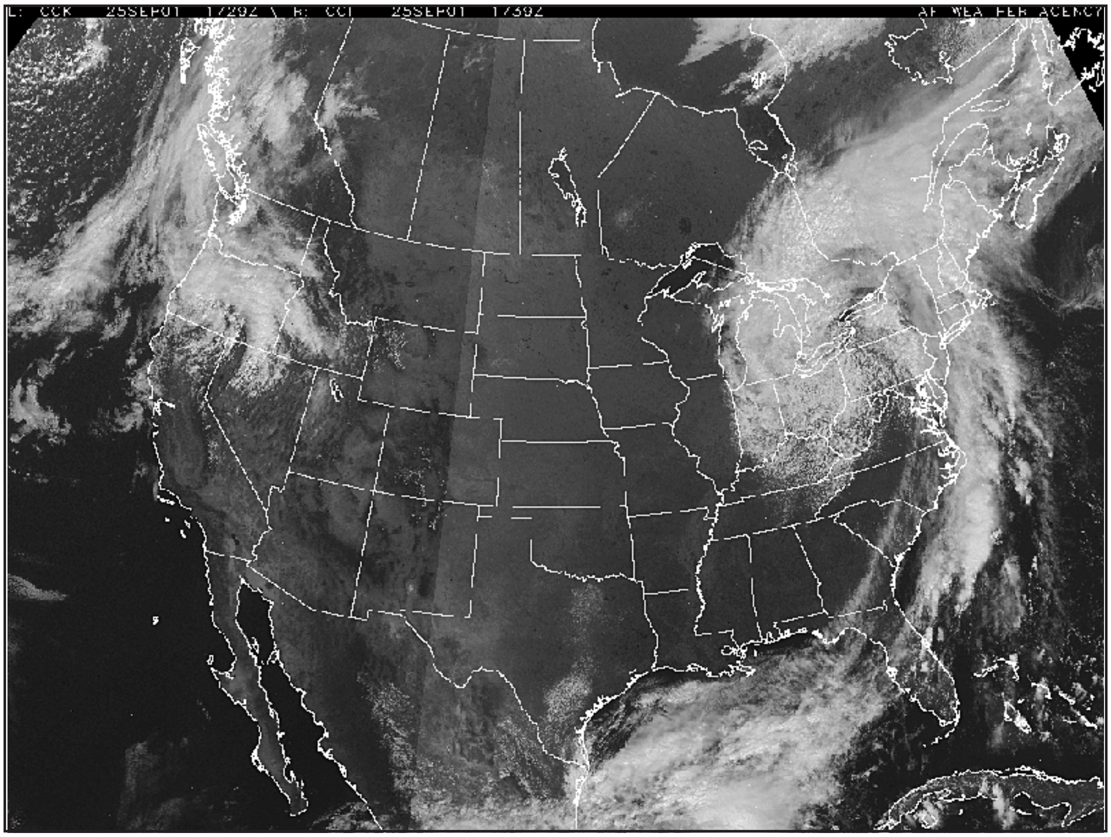

Figure 5-2. GOES Composite, 1734Z /25 September 2001. Satellite image approximately 5 1/2 hours later than Figure 5-1.

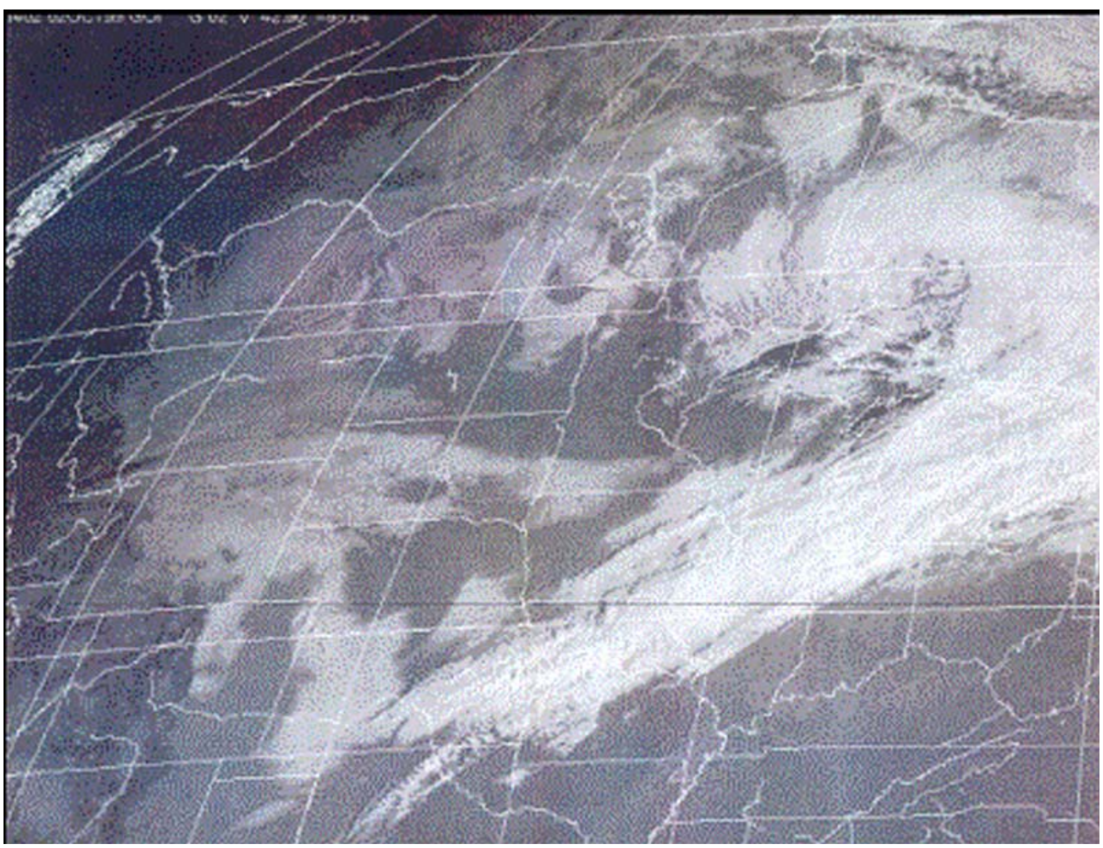

Figure 5-3. GOES East Visible, 1402Z/2 October 1999.

As mentioned earlier, a quiet period generally occurs in late September and continues through October. Maritime and continental polar air masses transit across the United States bringing pleasant weather over most of the country. Forecasters should not become complacent about these quiet periods; of course the potential always exists for significant storm development as will be shown in the following examples.

SHORT WAVE REGIMES

Several low-pressure development areas and their subsequent movement towards/across the Great Lakes region is shown below. These systems are often associated with short waves although these regimes will interact with long wave regimes during the winter season.

Canadian Short Waves/Cyclogenesis Southern Canada One of the more common storm tracks that affects the Great Lakes/northeastern United States region during the cold season is shown in Figures 5-4 through 5-7. In Figure 5-5, a major trough lies over the eastern United States. At the surface, cyclogenesis occurs in southern Canada as developing short waves move southeastward. The Alberta low is one of these regimes. These intensifying systems follow a southeasterly course towards the Great Lakes as shown in Figure 5-6. The synoptic events shown in Figures 5-4 through 5-7 are 24 hours apart. In Figure 5-4, a surface low appears over northern Saskatchewan. In Figure 5-5, the upper level support is the weak Pacific short wave shown over western Canada (not noticeable within the northwest flow).

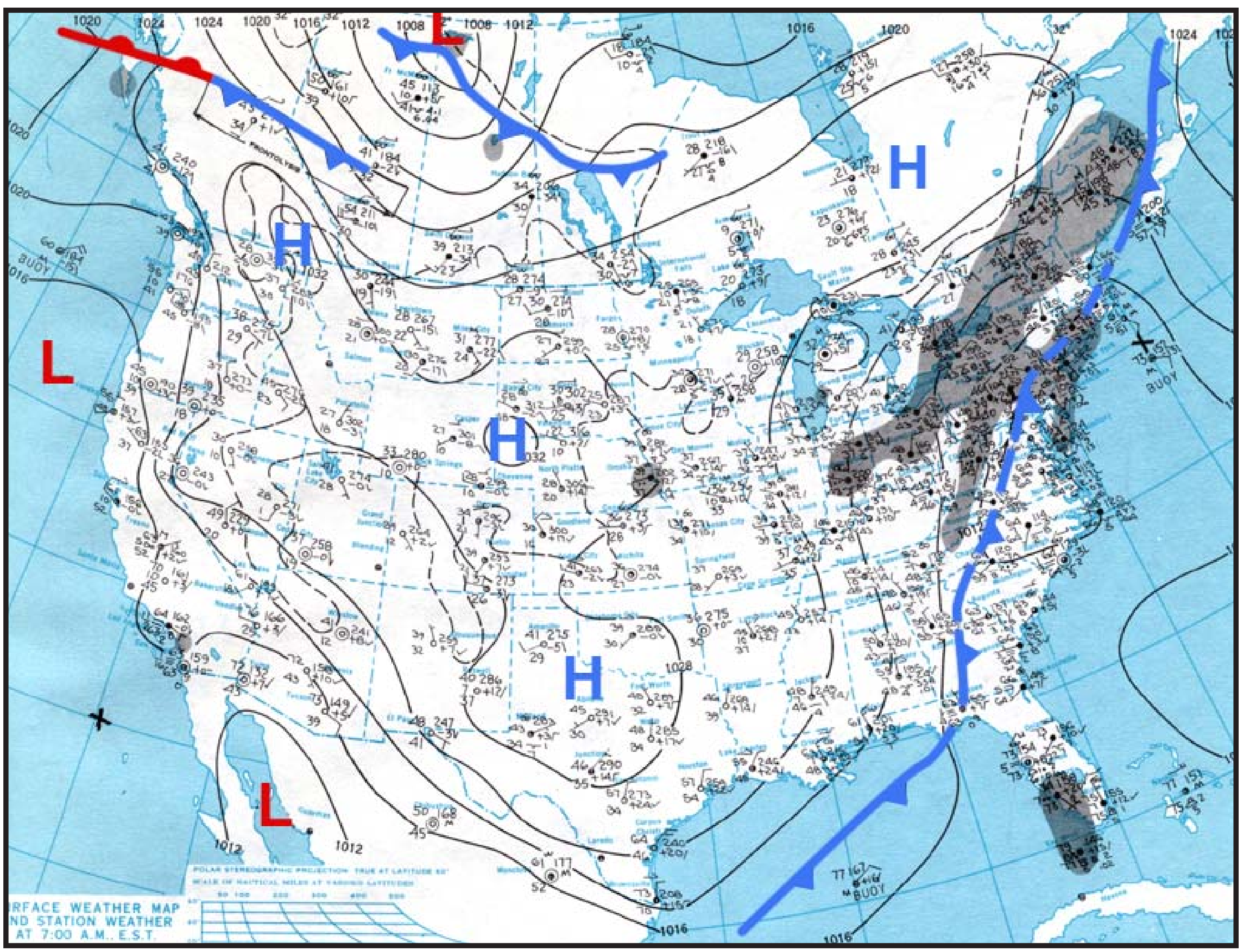

Figure 5-4. Surface Analysis Analysis, 1200Z/14 October 1978.

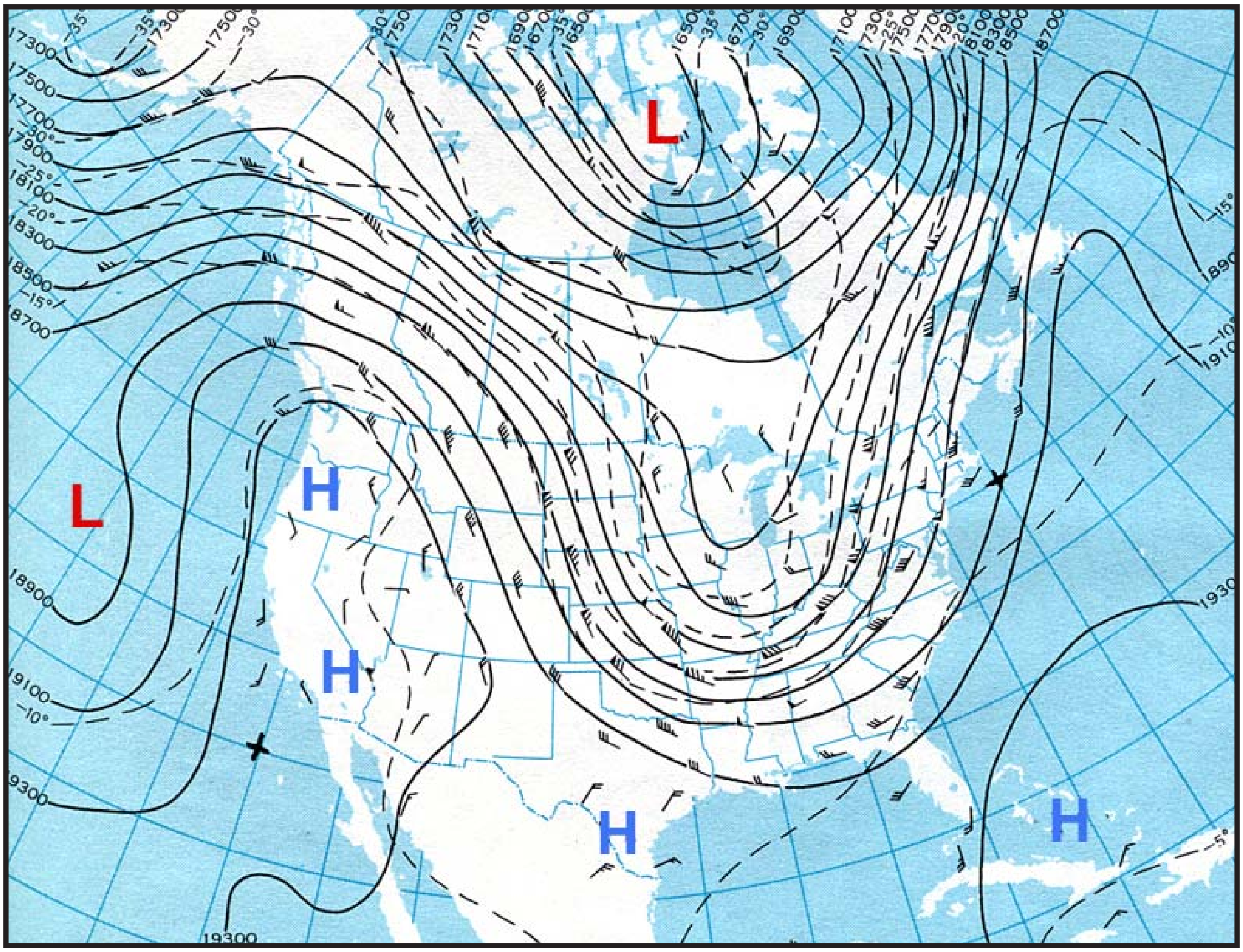

Figure 5-5. 500-mb Analysis, 1200Z/14 October 1978. Major trough lies over the eastern United States. Canadian short waves move southeastward within northwest flow.

Within twenty-four hours, Figure 5-6, the Saskatchewan low dropped rapidly southward into the northern United States. In the related 500-mb illustration, Figure 5-7, a weak kink in the contours over the northern Great Plains reveals the associated short wave.

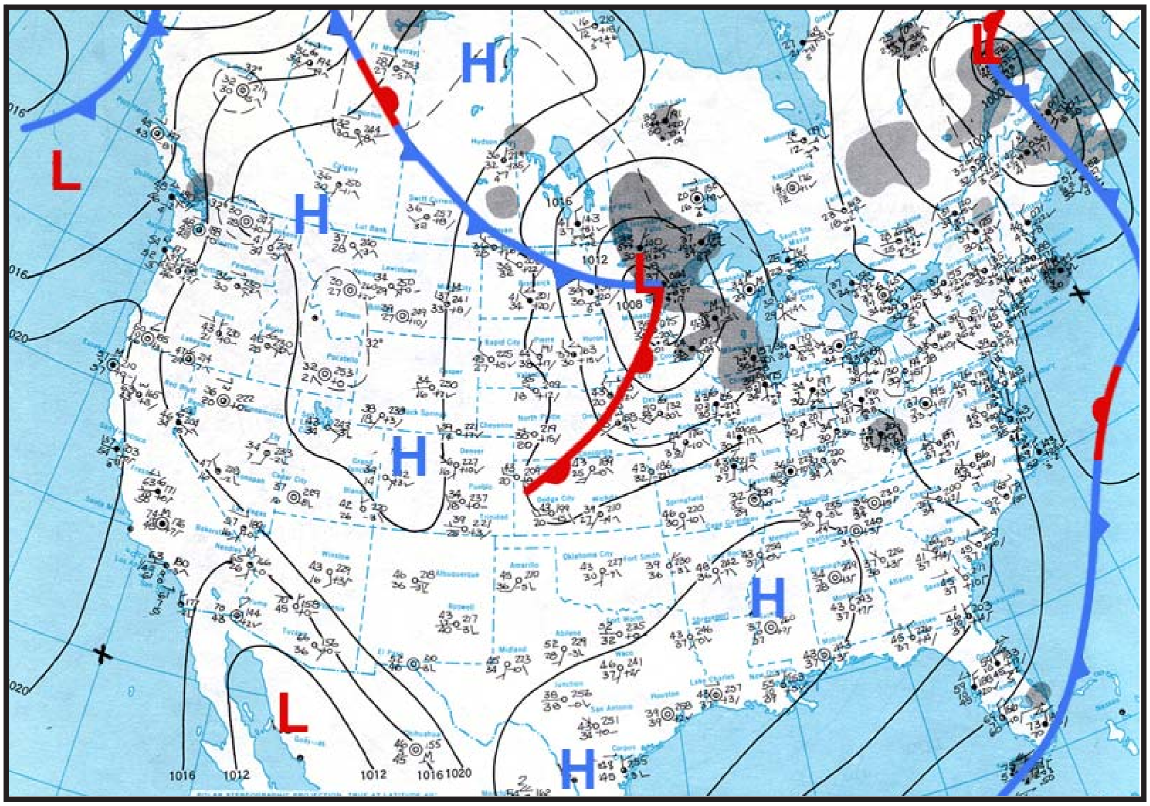

Figure 5-6. Surface Analysis, 1200Z/15 October 1978.

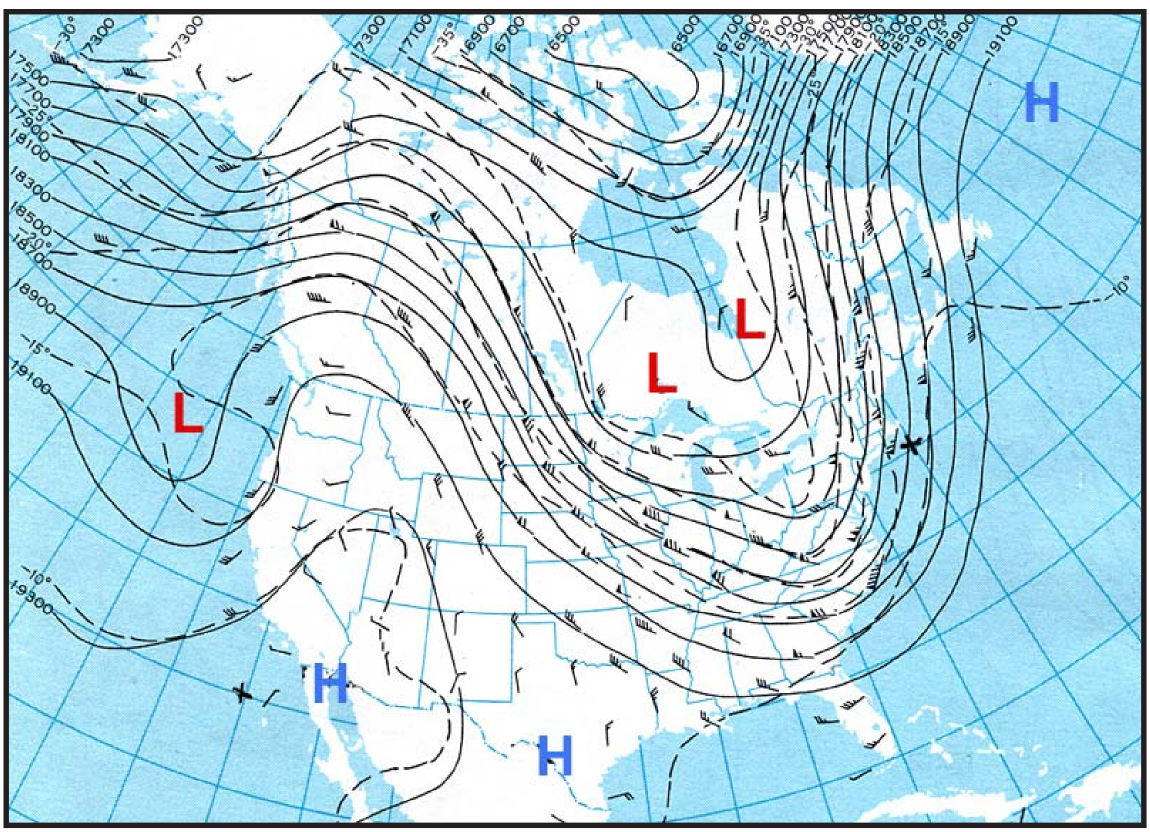

Figure 5-7. 500-mb Analysis, 1200Z/15 October 1978. A weak "kink" in the contours within northwest flow over the Northern Plains reveals a short wave with the surface system.

Western/Central United States Short Waves. Although storminess from the Great Plains that affects the eastern United States generally begins by mid-November, October can produce significant storms when major Pacific troughs move into the central United States. Several selected examples follow.

In Figure 5-8, short waves appear over the western United States and the Atlantic Ocean. The western trough is strong both in the pressure and thermal fields. At the surface (Figure 5-9), a disorganized pressure pattern is associated with the two fronts. The modified polar front shown over the southern Great Plains is moving northward bringing maritime tropical moisture into the central United States. At the same time, a continental polar (cP) cold front is plunging southward across the northern plain states advecting cold air into the developing disturbance.

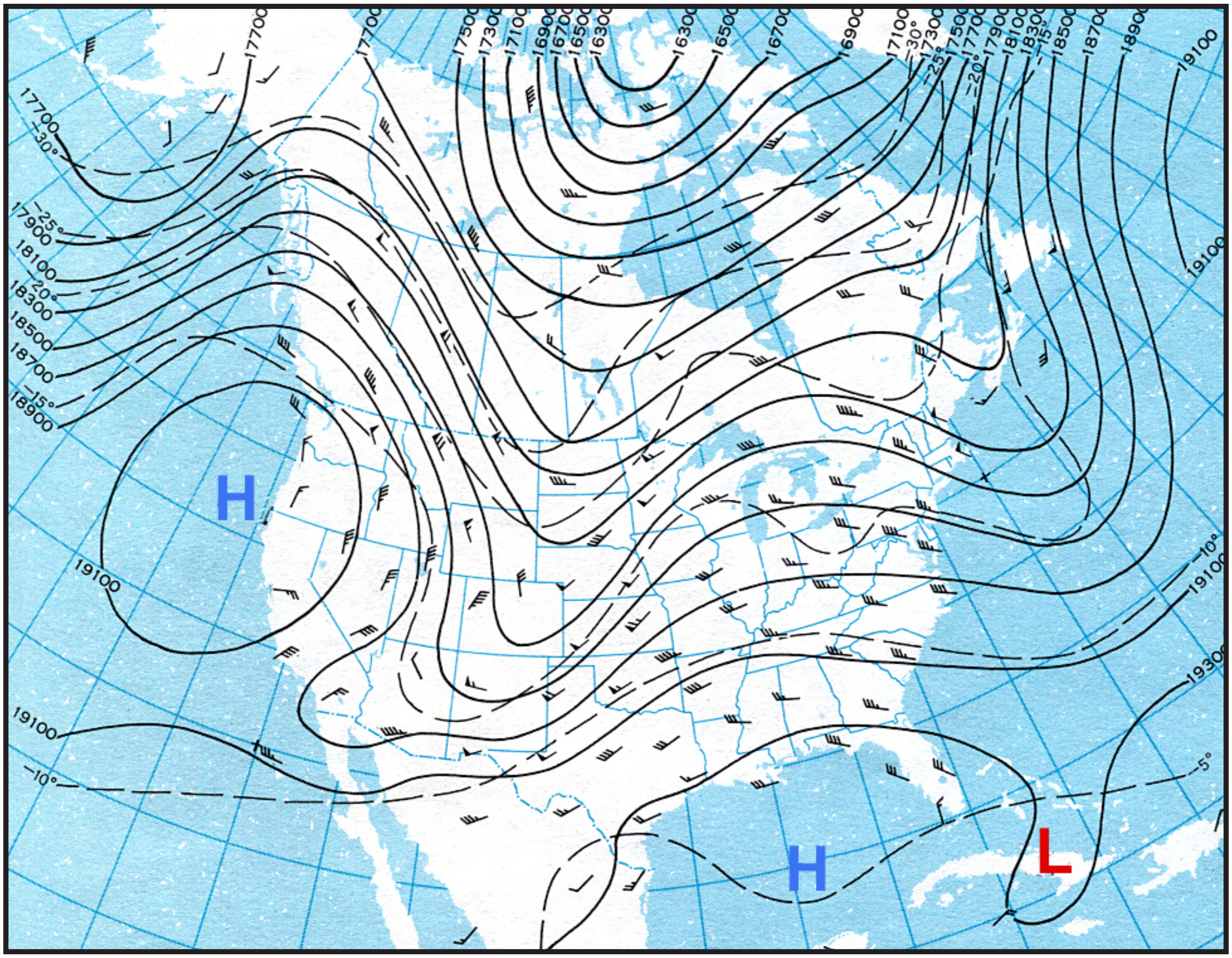

Figure 5-8. 500-mb Analysis, 1200Z/17 October 1981.

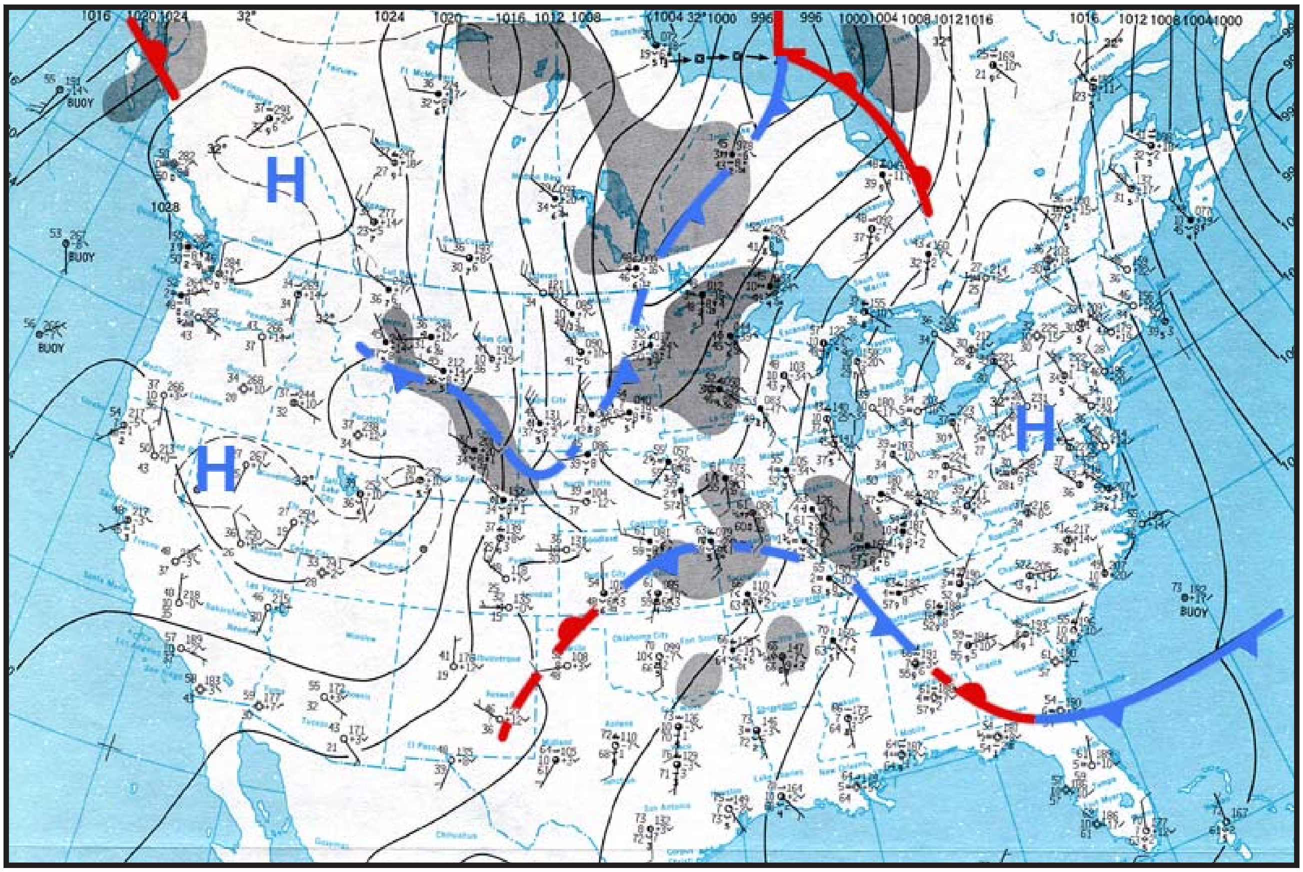

Figure 5-9. Surface Analysis, 1200Z/17 October 1981.

Figures 5-10 and 5-11 depict the synoptic pattern twenty-fours later. In Figure 5-10, the 500-mb trough has strong pressure and thermal gradients and is supported by a jet stream of greater than 100 knots.

At the surface (Figure 5-11), an intense low-pressure system appears over the eastern United States. Storm organization most likely occurred over Missouri 12 hours earlier (no data available).

Figures 5-12 through 5-15 illustrate another example of cyclogenesis over the central United States that affected the Great Lakes. In Figure 5-12, at the beginning of autumn, a weak short wave within zonal flow appears over the Rocky Mountains and western Great Plains region. The amplitude of the associated thermal trough over the Rockies suggests further deepening. The surface response is a developing frontal wave over Kansas as shown in Figure 5-13.

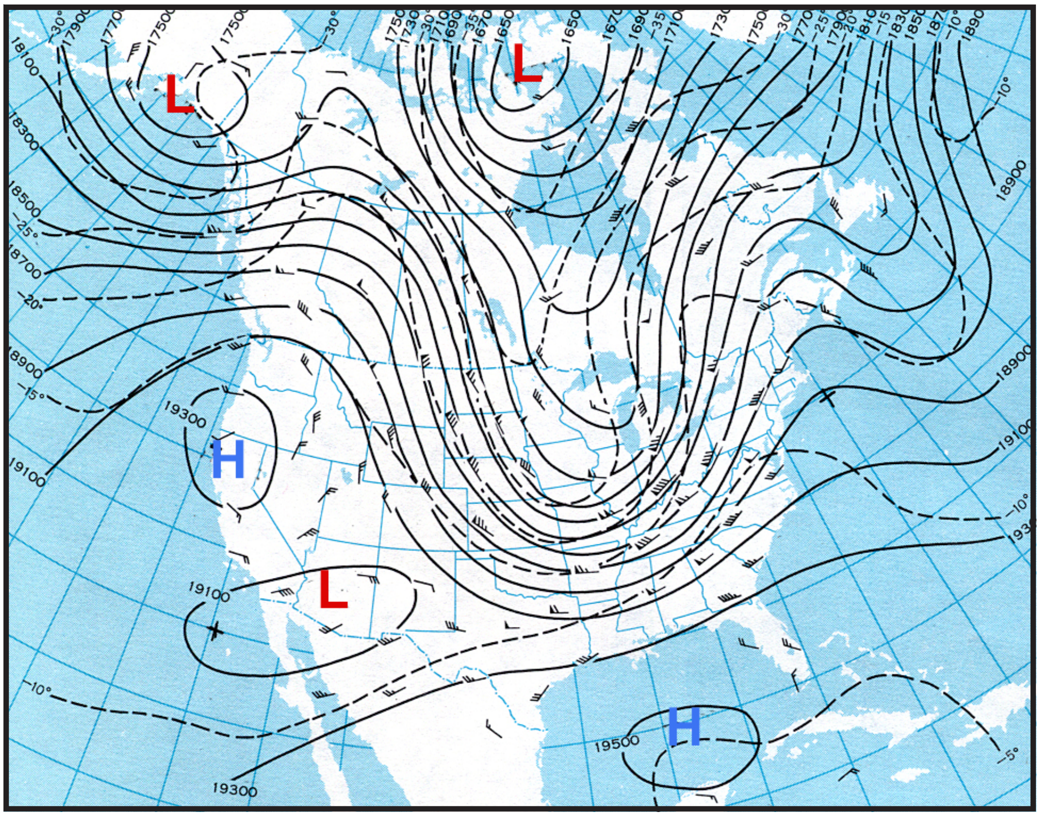

Figure 5-10. 500-mb Analysis, 1200Z/18 October 1981

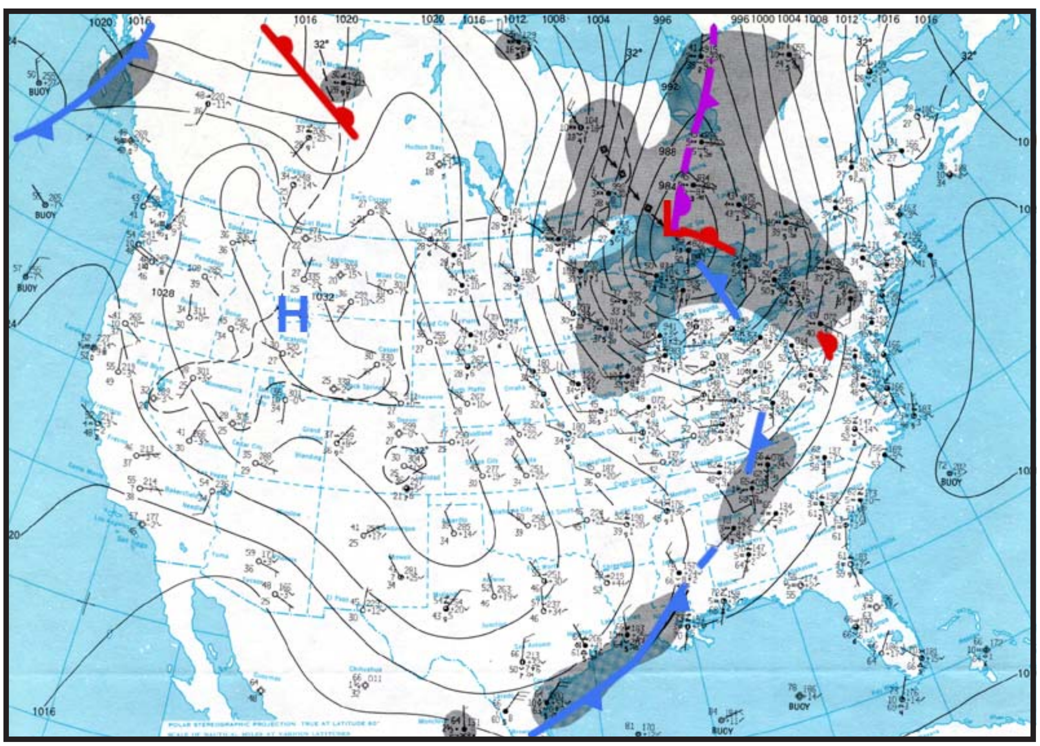

Figure 5-11. Surface Analysis, 1200Z/18 October 1981.

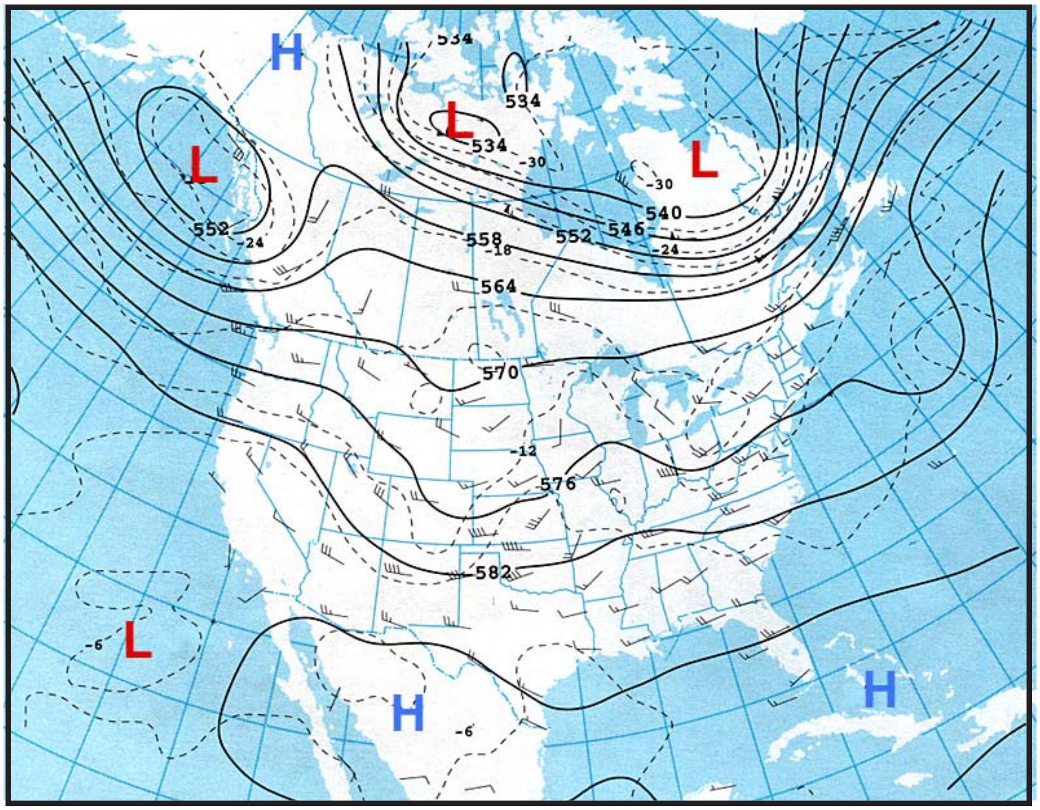

Figure 5-12. 500-mb Analysis, 1200Z/18 September 2001. Weak short wave has moved into the western Great Plains. Subtropical ridge stretches across Mexico and Gulf of Mexico.

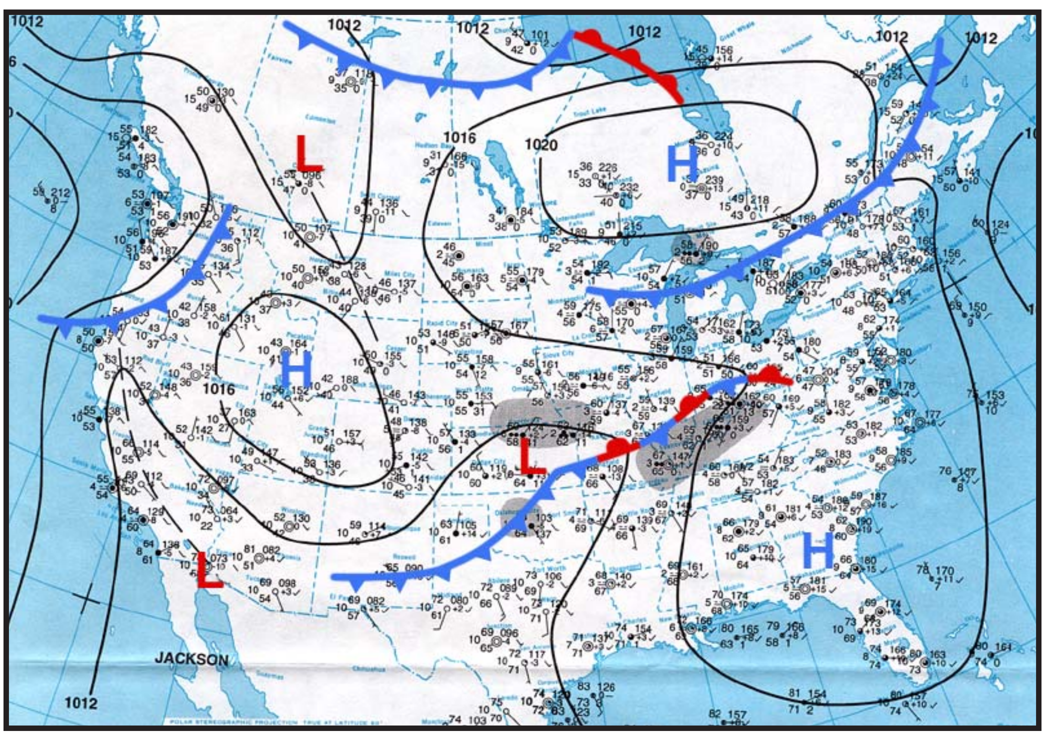

Figure 5-13. Surface Analysis, 1200Z/18 September 2001. Frontal wave/low has developed as the short wave approaches. Dew points south of the wave are in the high 60s (° F) as gulf flow continues northward.

Figures 5-14 and 5-15 depict the developing system two days later. In Figure 5-14, the 500-mb trough has continued to deepen with a closed low located over the Great Lakes. Likewise, the Kansas frontal wave shown in Figure 5-13 (two days earlier) recurves northeastward across northern Missouri and stacks with the upper low (Figure 5-15).

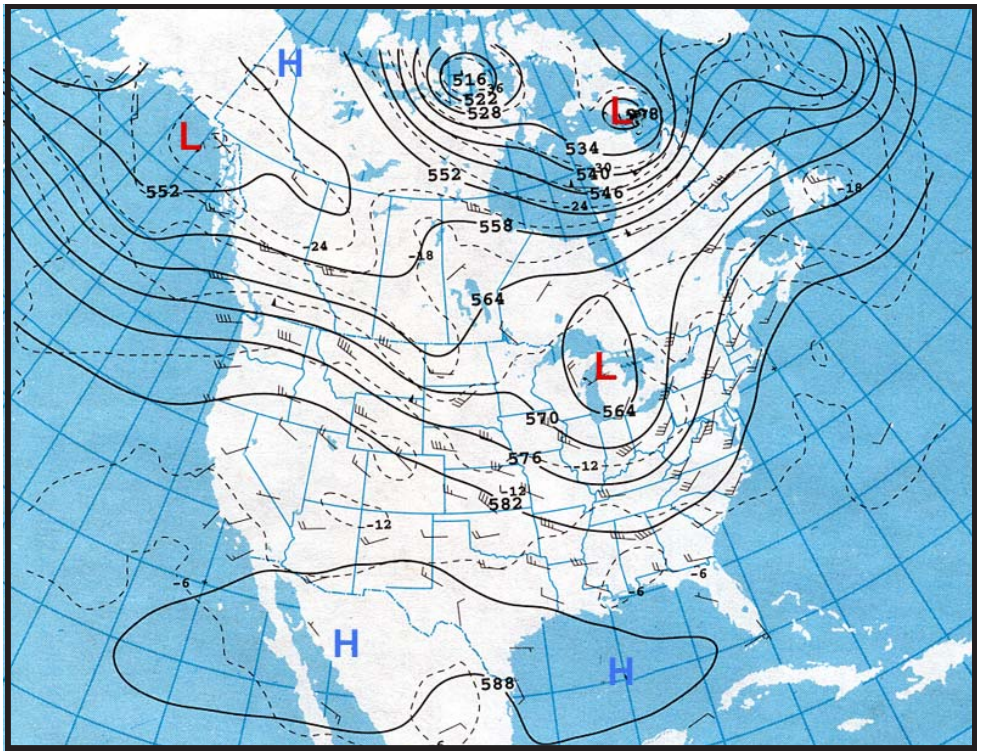

Figure 5-14. 500-mb Analysis, 1200Z/20 September 2001.

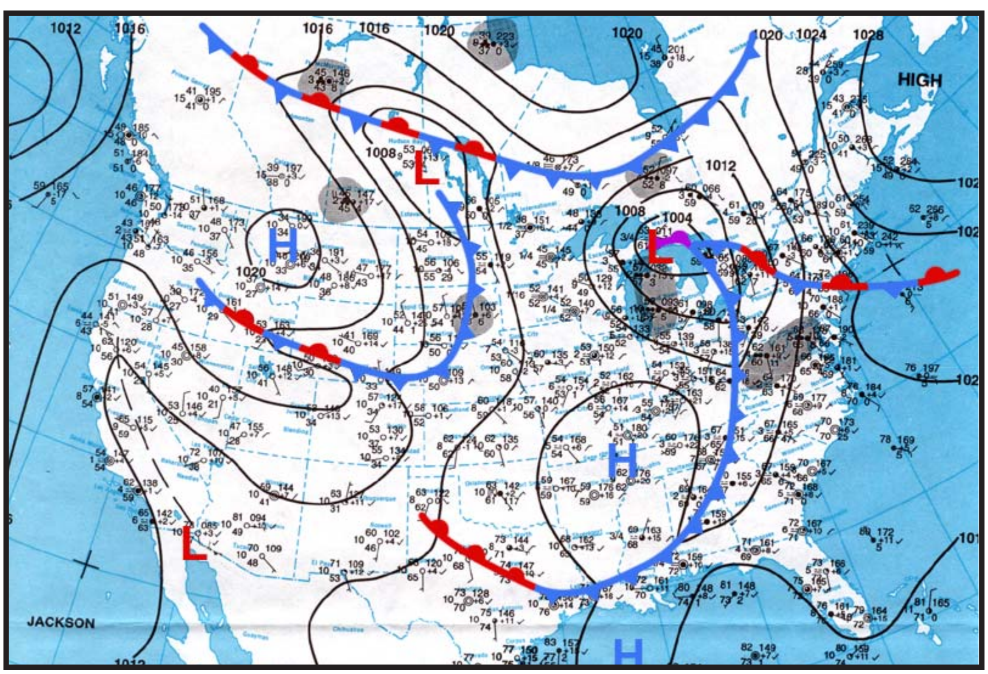

Figure 5-15. Surface Analysis, 1200Z/20 September 2001.

EAST COAST CYCLOGENESIS.

During the winter season, frontal waves that developed either along or offshore of the East Coast and/or Gulf of Mexico can become intense winter storms with strong winds and heavy snowfall during a short period of time.

Although infrequent during most of autumn, waves that do develop along stationary polar fronts over the eastern seaboard may become significant coastal storms within 24 hours. It is often too warm to produce a significant interior snowstorm as the coastal low moves northward except, perhaps, the Maine/southeastern Canada region. Figures 5-16 through 5-19 depict a coastal low event. A strong 500-mb short wave has been moving eastward from the Pacific Northwest and is currently over the central region of the United States (Figure 5-16).

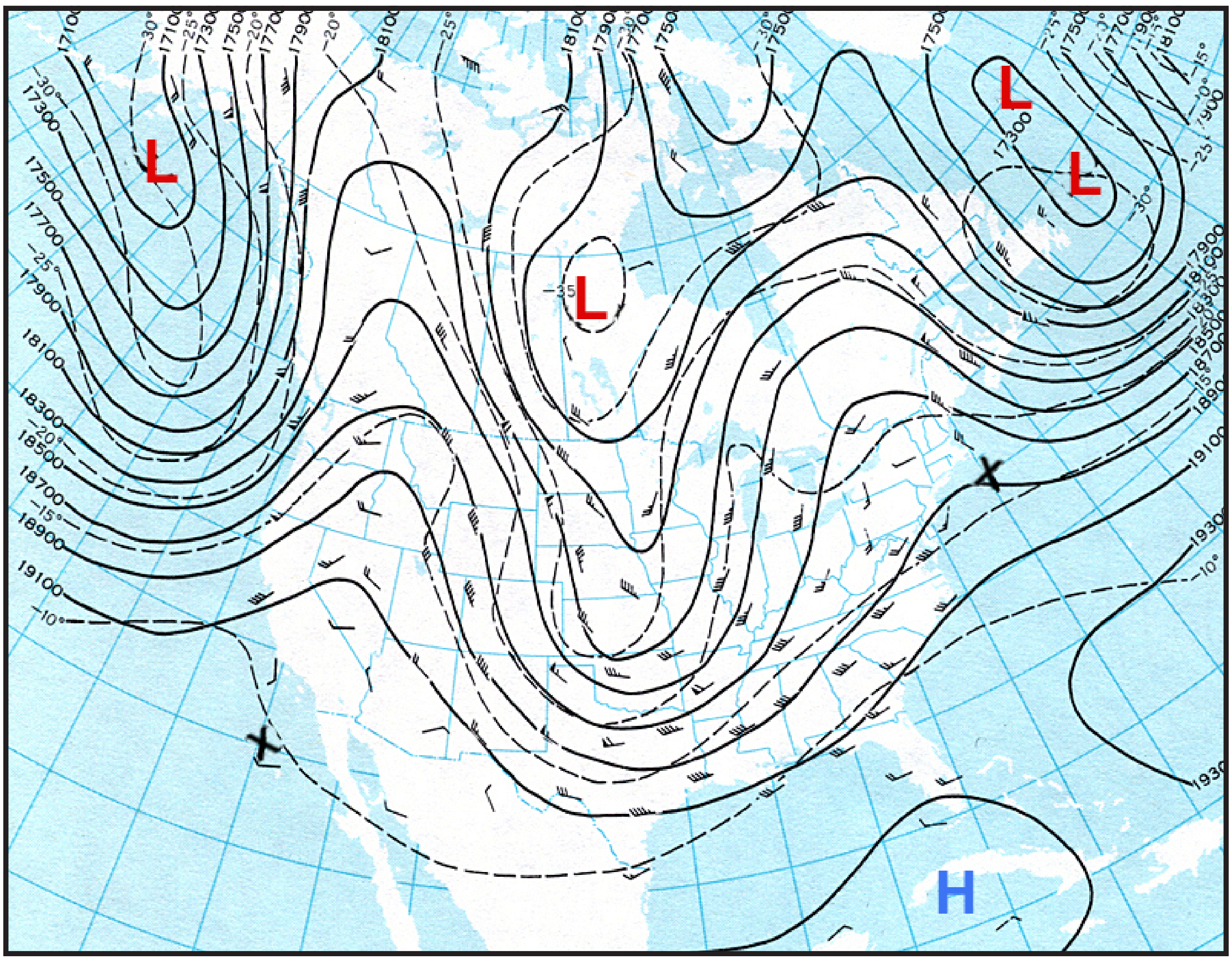

Figure 5-16. 500-mb Analysis, 1200Z/24 October 1980.

In the surface chart shown in Figure 5-17, the short wave's frontal system is shown from Wisconsin to Louisiana. A stationary front has been lying across the eastern Gulf of Mexico, central Florida and into the Atlantic Ocean for the past 72 hours. A frontal wave developed along this stationary front as shown in Figure 5-17. No model data was available so it is assumed that positive vorticity advection (PVA) existed over the wave since this disturbance was still some distance from the approaching Midwest short wave.

Figures 5-18 and 5-19 show the developing East Coast storm 24 hours later. In Figure 5-18, the short wave has become negativity-tilted trough (negativity-tilted troughs are related to strong to

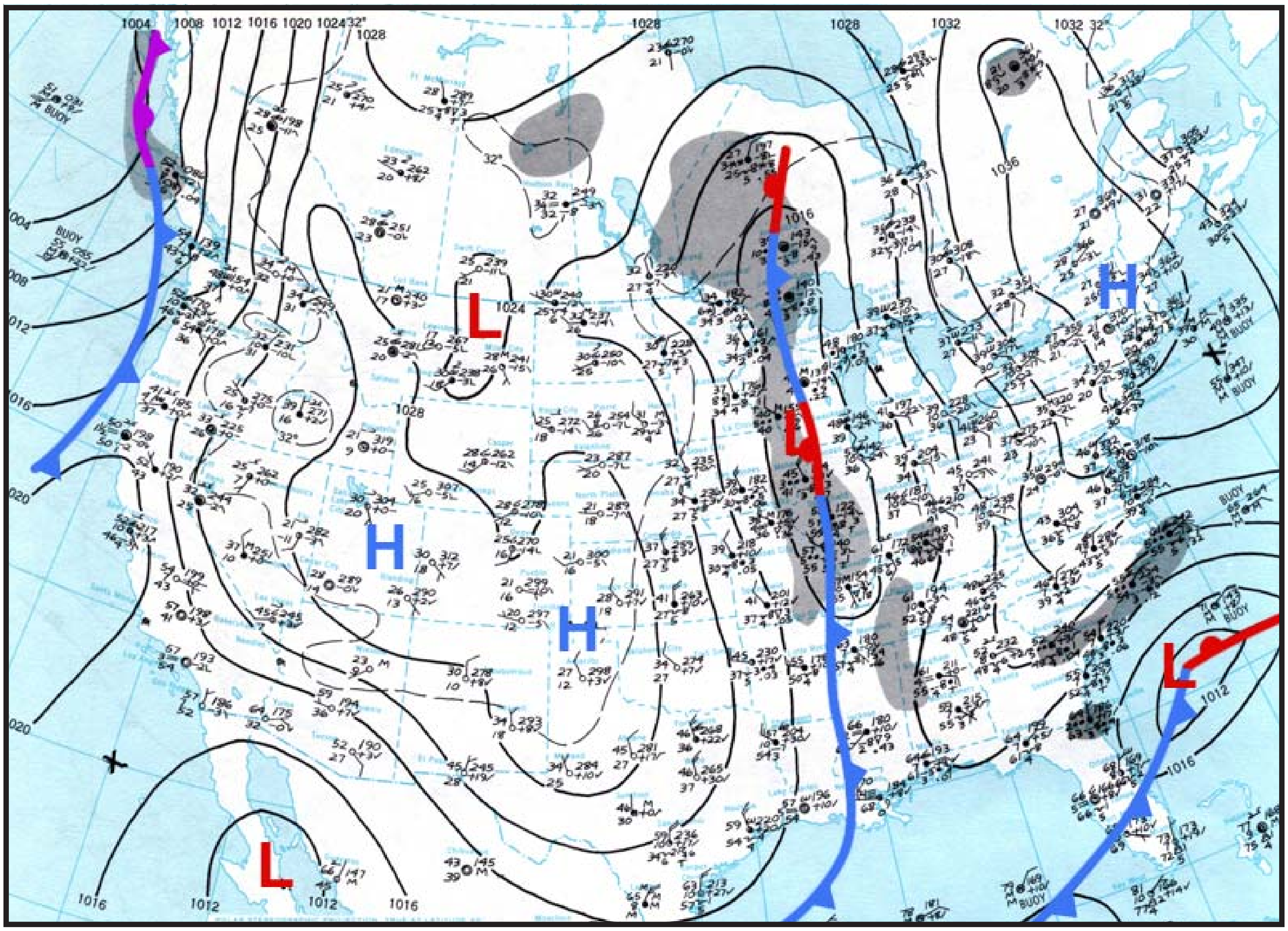

Figure 5-17. Surface Analysis, 1200Z/24 October 1980.

intense storm systems). Strong pressure and thermal gradients and the jet stream can be seen in Figure 5-18.

The frontal wave located off the Carolina/Georgia coast in Figure 5-17 had moved northward to Virginia and intensified as illustrated in Figure 5-19. Within 24 hours, the two fronts merged offshore; the Virginia low continued to deepen as it moved northward and appeared over southeastern Quebec by 1200Z the following day (976mb central pressure – not shown).

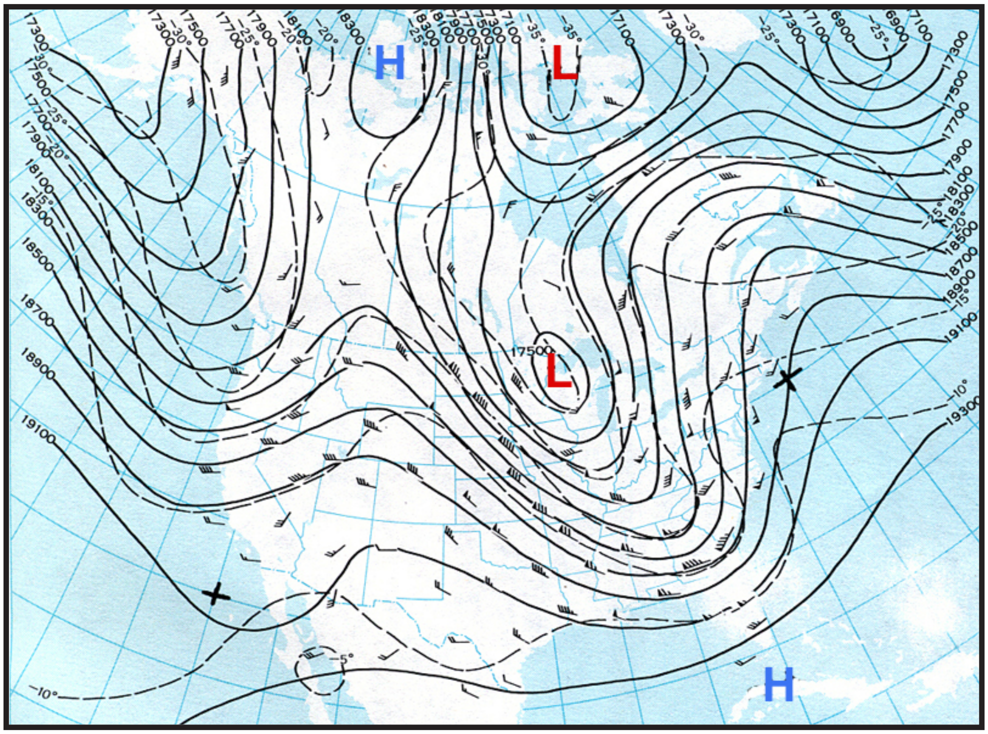

Figure 5-18. 500-mb Analysis, 1200Z/25 October 1980.

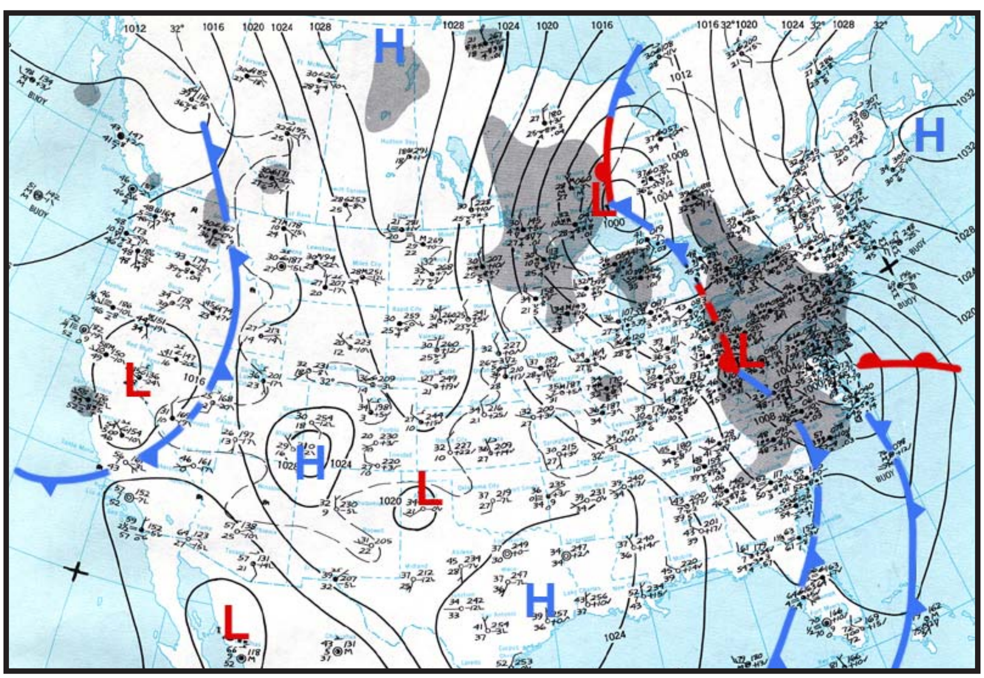

Figure 5-19. Surface Analysis, 1200Z/25 October 1980.

GULF OF MEXICO CYCLOGENESIS

This cyclogenesis regime, along with the East Coast regime just presented, occurs more often during the winter season. In this event, frontal cyclogenesis occurred over the western Gulf of Mexico as a low-latitude short wave (split flow) moved across Arizona and New Mexico (Figure 5-20).

At the surface (Figure 5-21), an extensive polar high-pressure system is shown across most of the nation (prevailing high regime - a winter pattern).

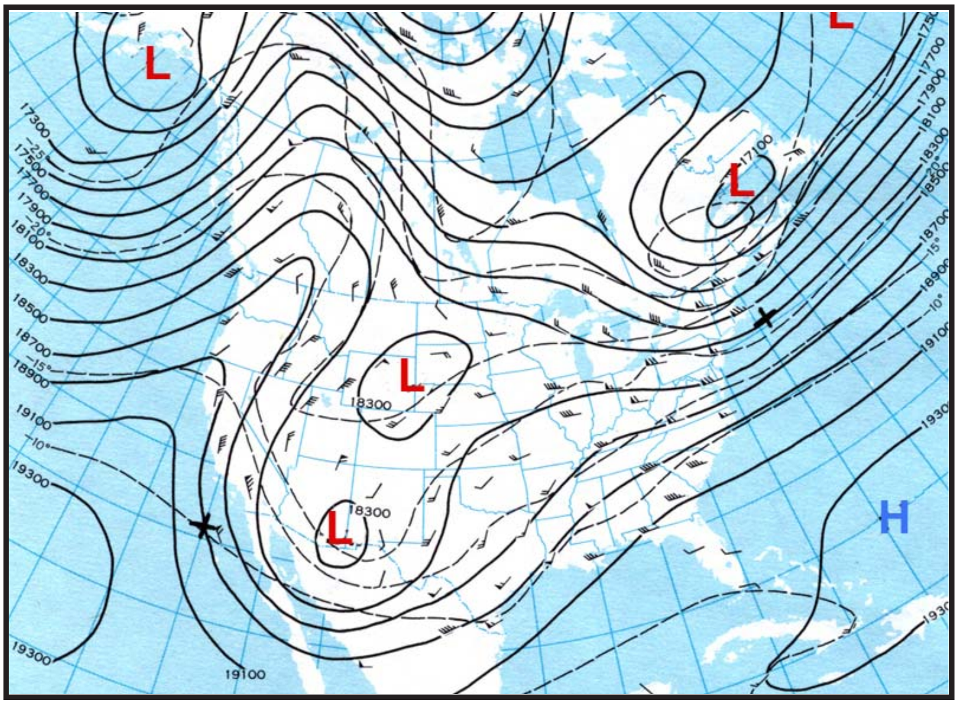

Figure 5-20. 500-mb Analysis, 1200Z/16 November 1980.

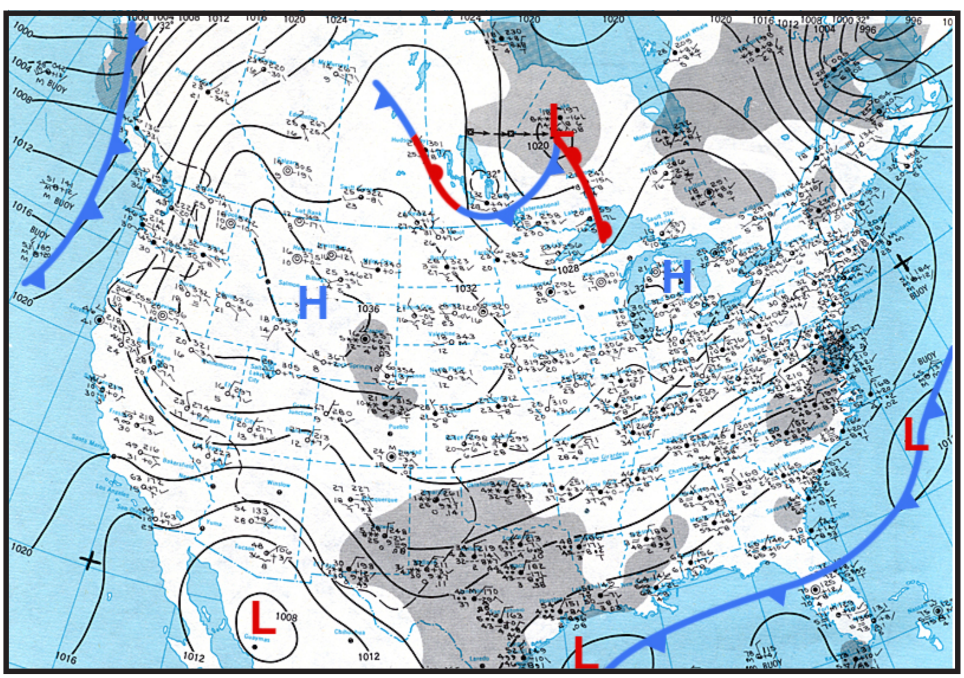

Figure 5-21. Surface Analysis, 1200Z/16 November 1980.

Twenty-fours later, the upper low has moved into the Southern Plains states as shown in Figure 5-22.

The frontal wave shown earlier in Figure 5-21 over the western Gulf of Mexico has lifted northward into Mississippi in response to the approaching upper low as shown in Figure 5-23. The shallow polar ridge east of the Appalachian Mountains (damming) can be seen; gulf moisture will continue to spread northward over the shallow ridge.

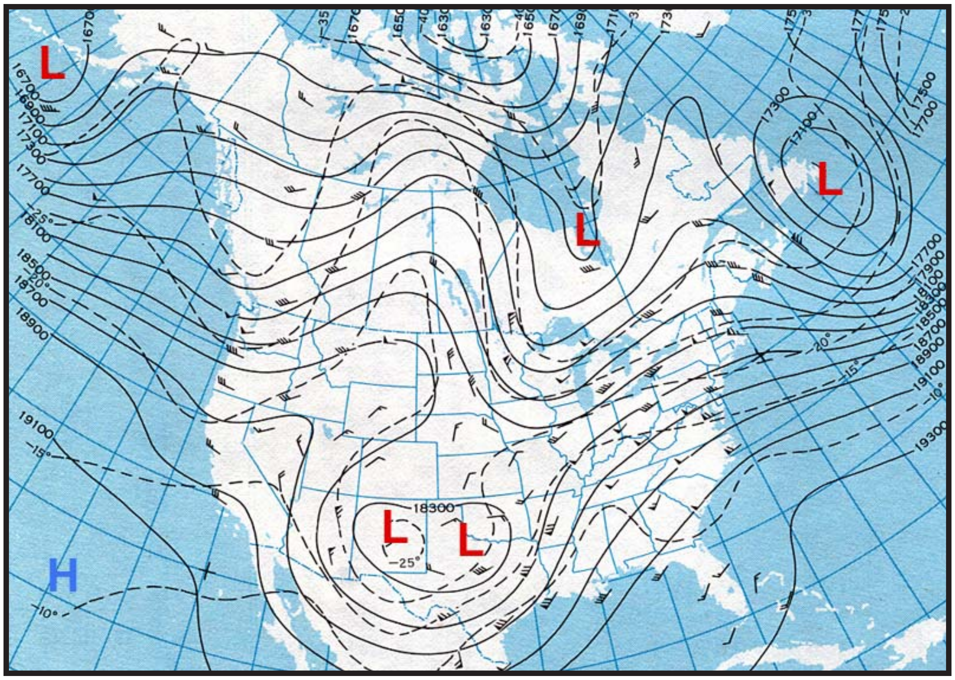

Figure 5-22. 500-mb Analysis, 1200Z/17 November 1980.

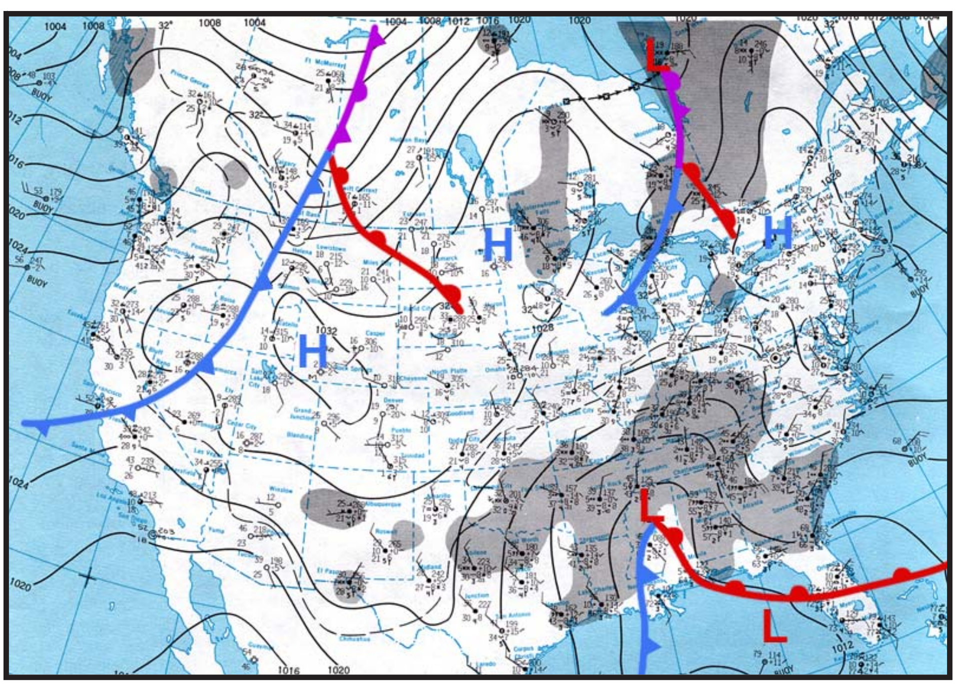

Figure 5-23. Surface Analysis, 1200Z/17 November 1980.

Figure 5-24 depicts the developing storm 24 hours later. Measurable snow has occurred from the western Virginia and Pennsylvania region northeastward to Maine.

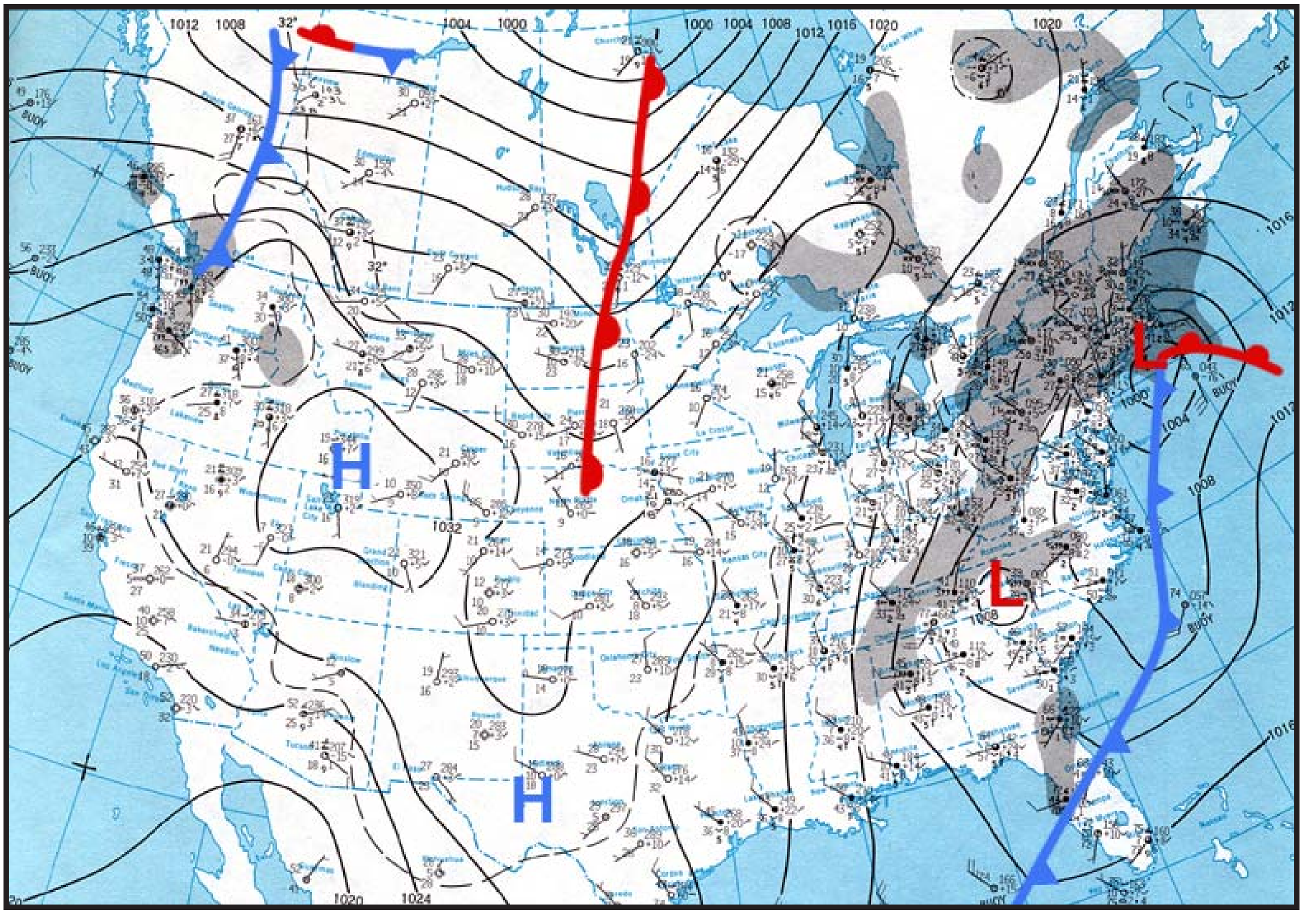

Figure 5-24. Surface Analysis, 1200Z/18 November 1980.

CUTOFF LOWS

Cutoff low discussions were presented earlier in Chapters 3 and 4. Cutoff lows are less frequent over the eastern United States during autumn prior to the arrival of the stronger westerlies and polar jet (Figures 5-25 and 5-26).

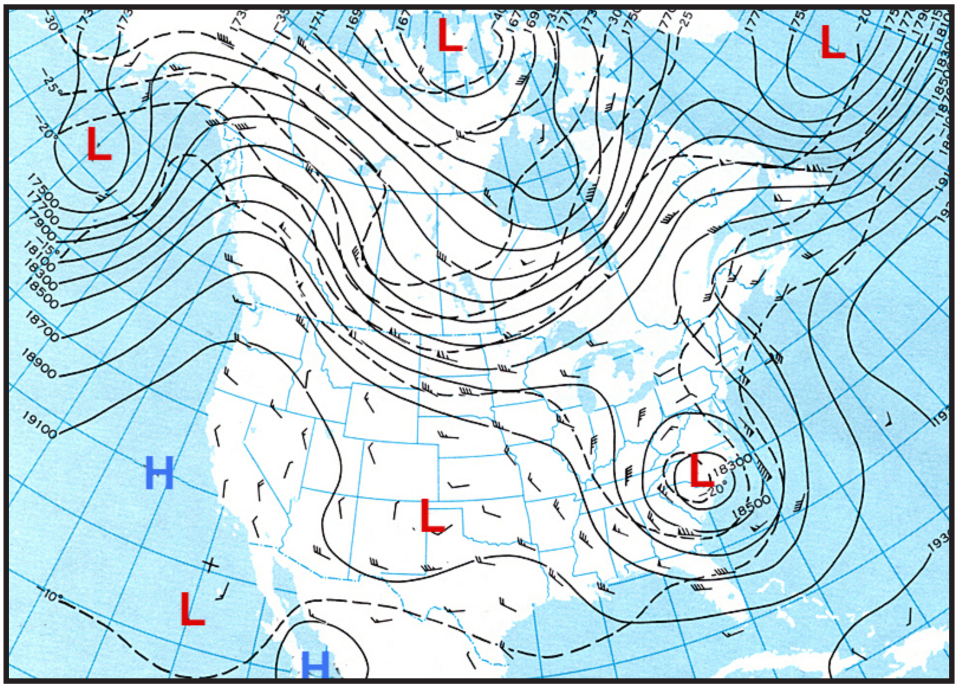

Figure 5-25. 500-mb Analysis, 1200Z/14 October 1977.

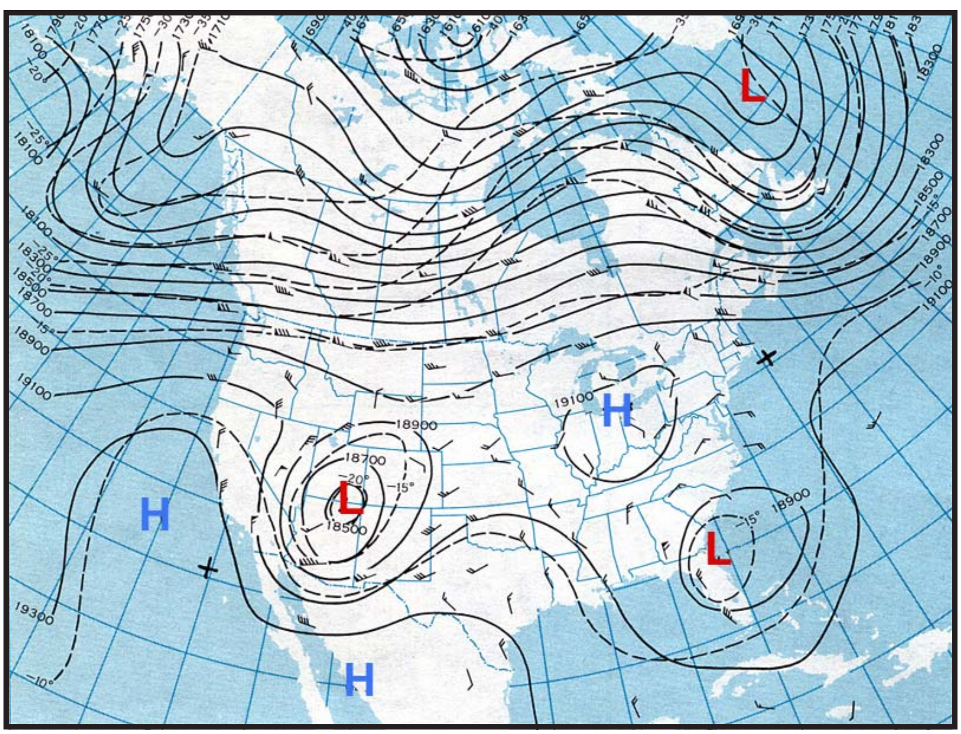

Figure 5-26. 500-mb Analysis, 1200Z/3 November 1978.

THUNDERSTORMS

Summer's regime of daily convection may extend into early autumn as shown in Figure 5-27. However, thunderstorm occurrences lessen throughout autumn as more stable polar air masses move across the region (also decreased insolation). Most thunderstorm activity is associated with frontal systems, upper troughs and cold pockets (Figures 5-28 and 5-29).

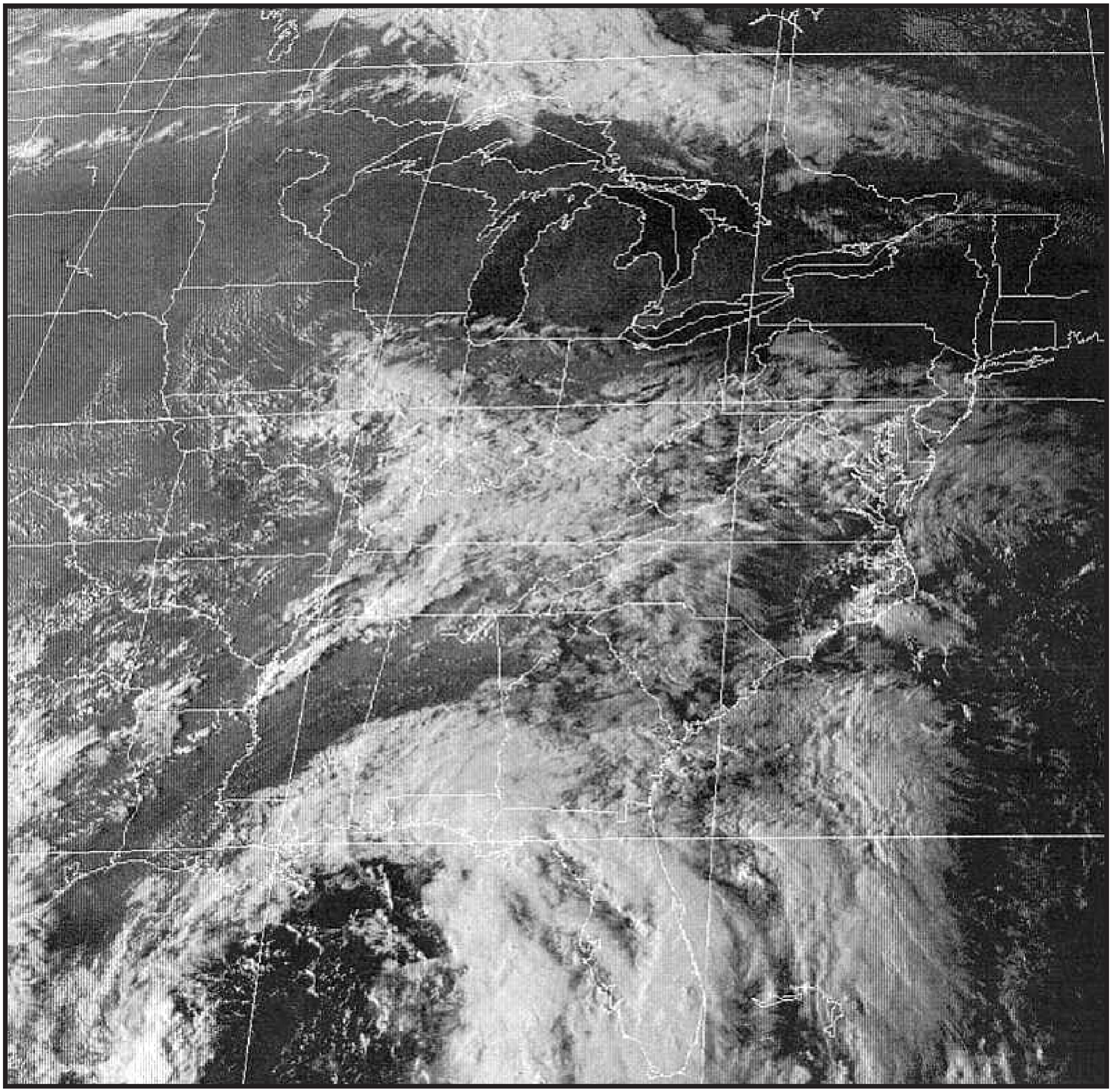

Figure 5-27. GOES East Visible, 2215Z/17 September 1998. Sea breeze thunderstorms can be seen along the Gulf Coast.

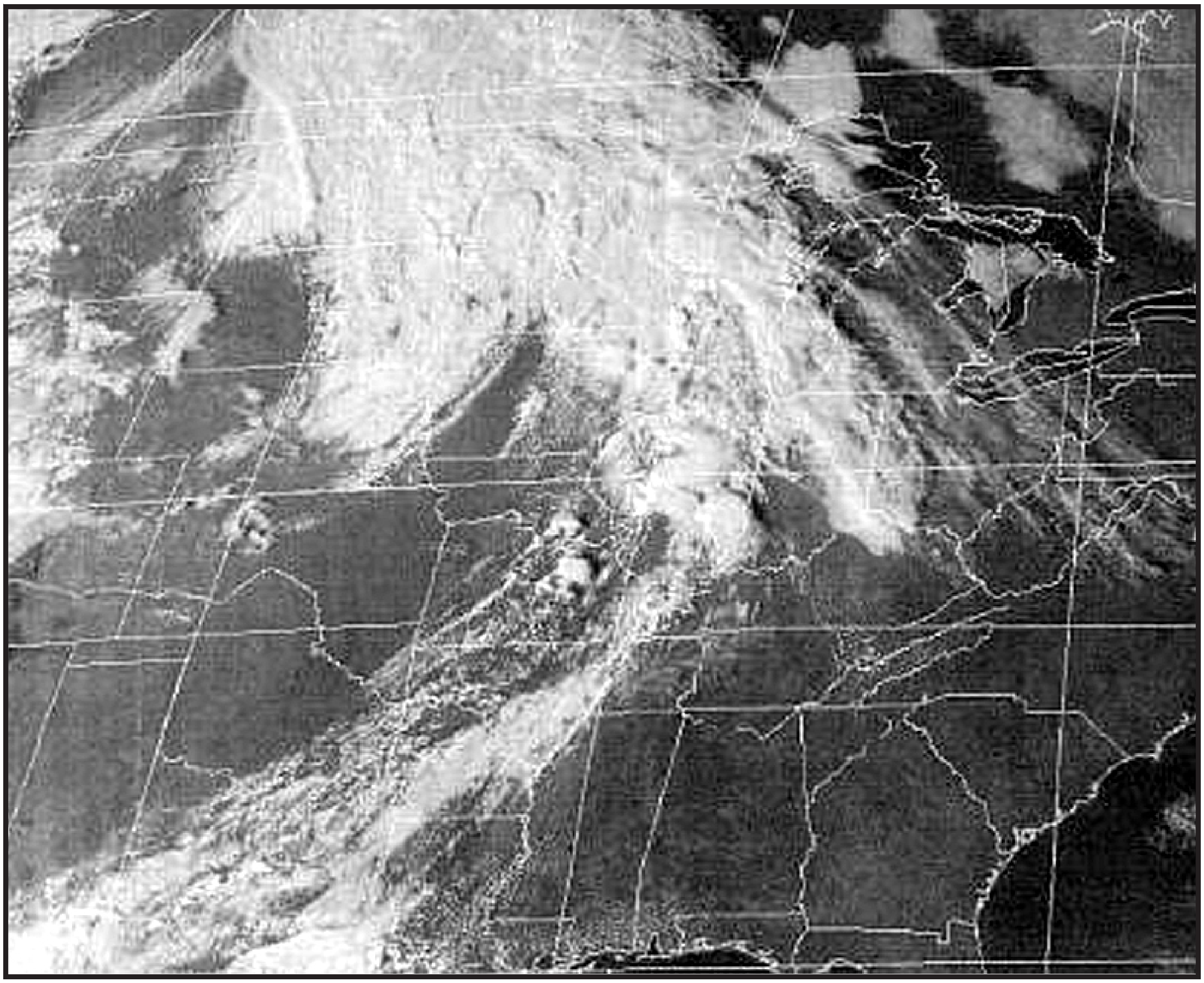

Figure 5-28. GOES East Visible, 2045Z/29 October 1998.

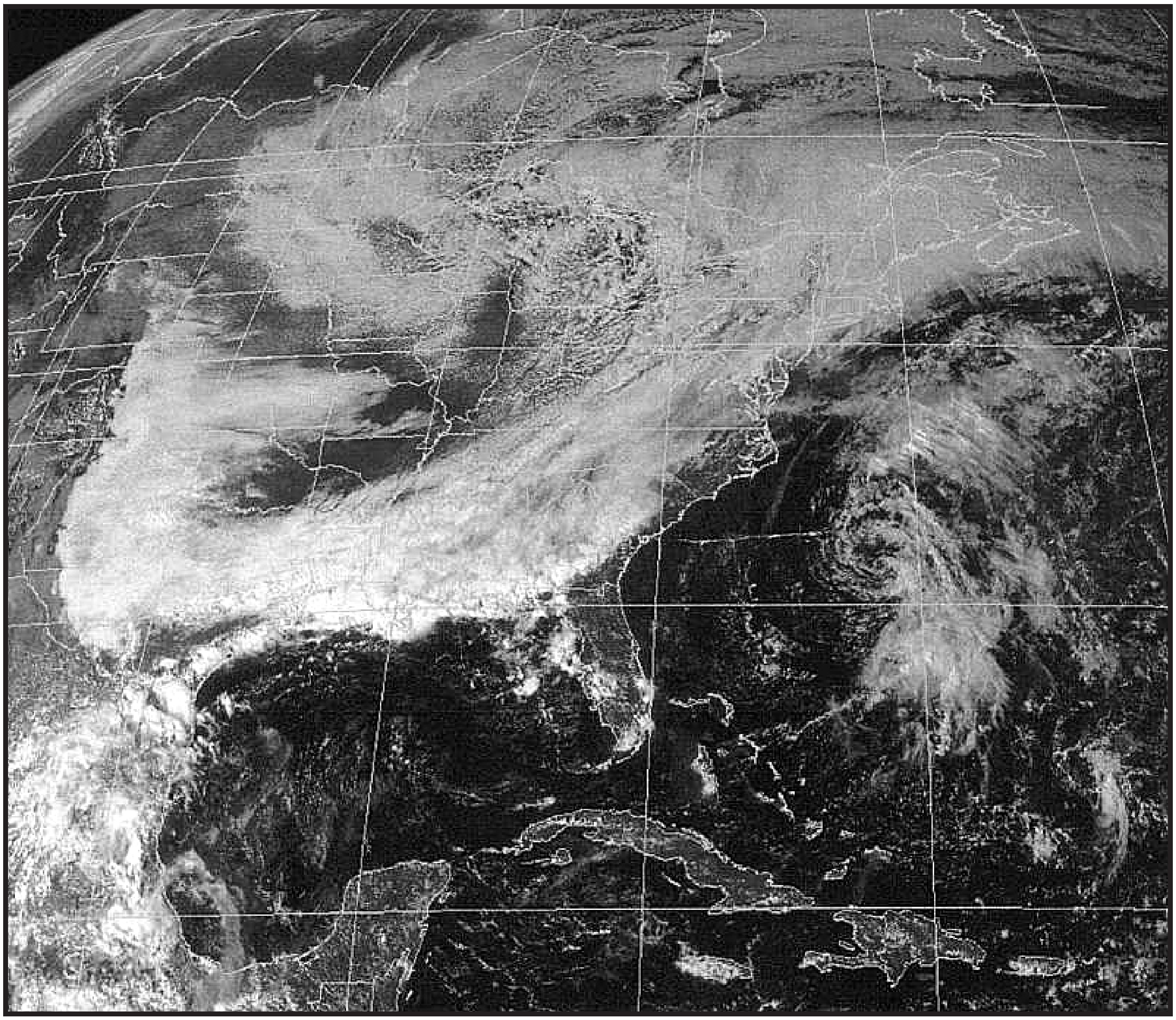

Figure 5-29. GOES East Visible, 1932Z/6 October 2000. Frontal thunderstorms can be seen over the southeastern United States

Along with a decrease in convection severe thunderstorm events become less frequent throughout autumn over the eastern United States. Figures 5-30 through 5-34 illustrates severe thunderstorm reports received across the United States during September and October 1998 and also September 2000 and October 2000 (data from AFWA's Severe Weather Section). The intent is to show the decrease in severe thunderstorms from summer regime's moist and unstable air during the early part of September to cooler, stable air masses in October. In the September 1998 illustration, Figure 5-30, a large part of the eastern United States experienced tornado and severe thunderstorm events. The next month, October 1998, no severe thunderstorms were reported over nearly all of the eastern United States (Figure 5-31). Figure 5-32 depicts the symbology for Figures 5-30 and 5-31.

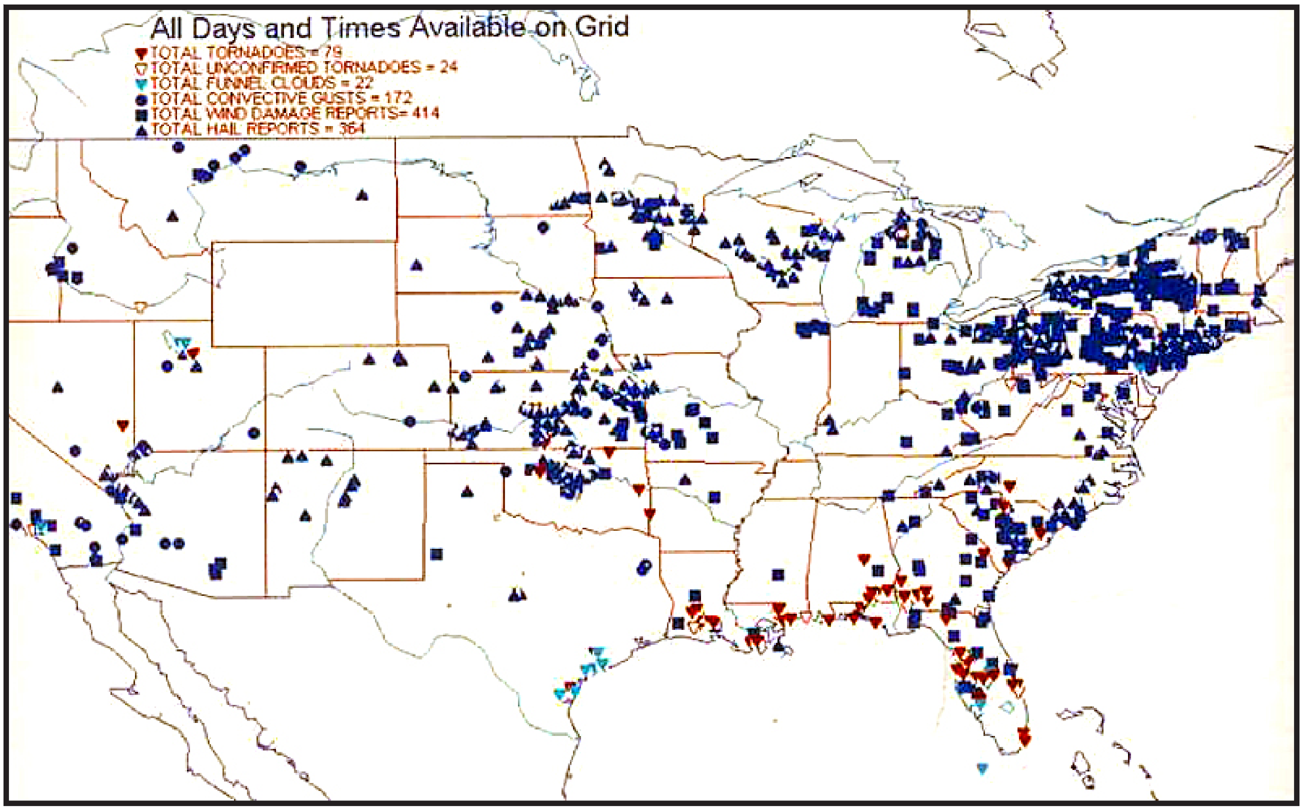

Figure 5-30. Tornado & Severe Thunderstorm Reports, Eastern United States, September 1998.

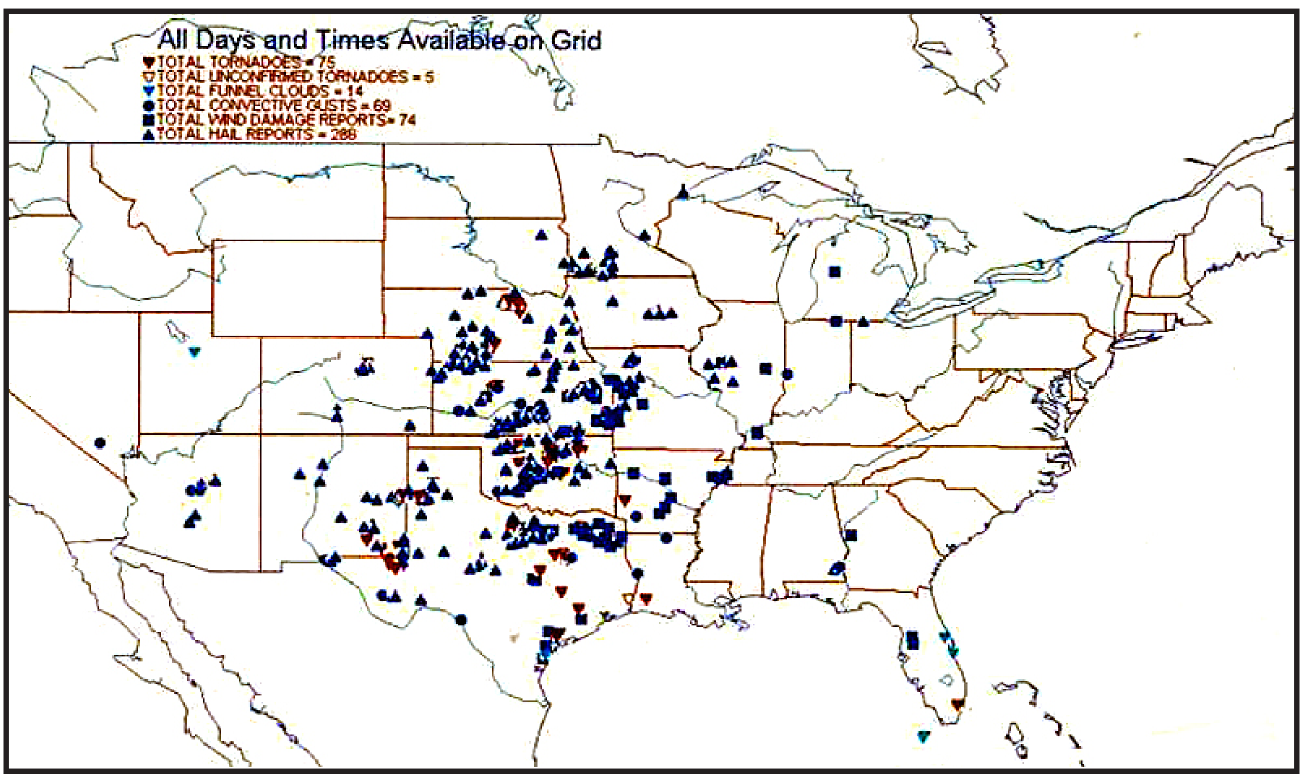

Figure 5-31. Tornado & Severe Thunderstorm Reports, Eastern United States, October 1998.

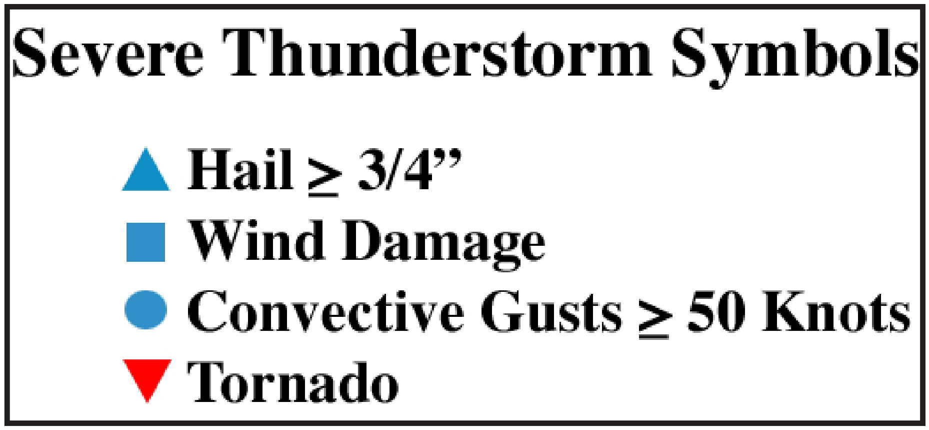

Figure 5-32. Severe Thunderstorm Symbols.

Severe thunderstorm reports for September and October 1999 through 2001 were presented in Chapter 4 (Figures 4-77 through 4-82). In both years of 1999 and 2000, there was one major severe thunderstorm event in October of each year, otherwise, little severe activity occurred over the eastern United States. In the October figures for 1998 through 2001, very little, if any, severe thunderstorm reports are shown over the southeastern United States east of the Appalachians for the past four years. Based on this data, it appears that frontal systems become stationary over the Great Plains and allows for gulf moisture (and instability) to interact with these fronts prior to the arrival of upper support from the western United States. Often, developing frontal lows and associated severe thunderstorm areas (and upper support) lift northeastward from the central United States into the northeastern United States and Canada leaving the southeastern United States free of significant convection.

A case example will now be shown for October 4, 2000. In Figure 5-33, almost all of the eastern United States reported no severe thunderstorms except the reports shown over northern Ohio, southern New York and Pennsylvania and New Jersey. All these reports occurred with one event that will be presented next. Most activity is along and south of the stationary front. Severe thunderstorm events are likely when all the ingredients come together as will be shown in the following figures.

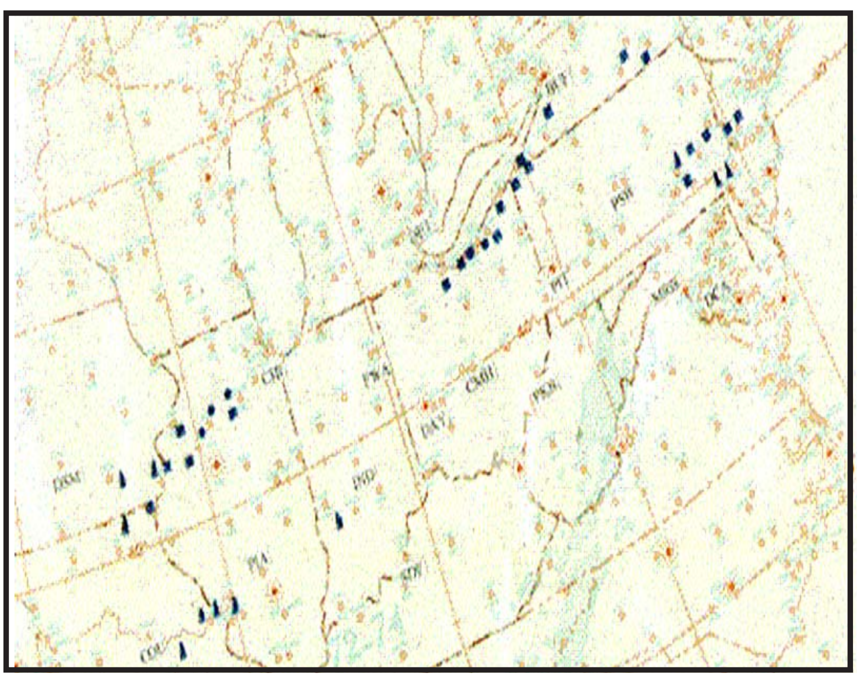

Figure 5-33. Severe Convective Reports, 4/0000Z -5/0000Z October 2000.

In this event, a stationary polar front is shown from Pennsylvania to Oklahoma (Figure 5-34). Strong thickness packing is shown behind the stationary polar front.

The boundary layer chart, Figure 5-35, shows summer-like moisture and thermal axis along and south of the stationary front (for almost 24 hours).

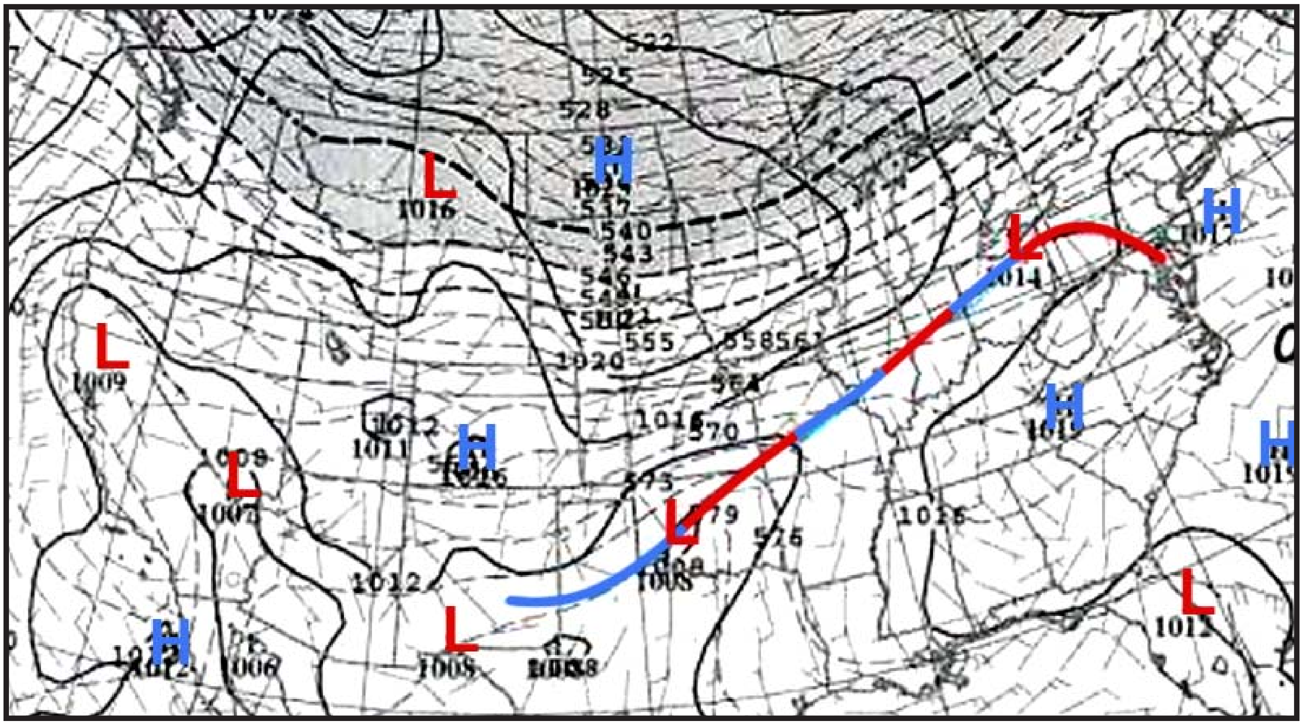

Figure 5-34. ETA 00-Hour Mean Sea-Level Pressure/1000- to 500-mb Thickness, 1200Z/4 October 2000. 1000 mb winds

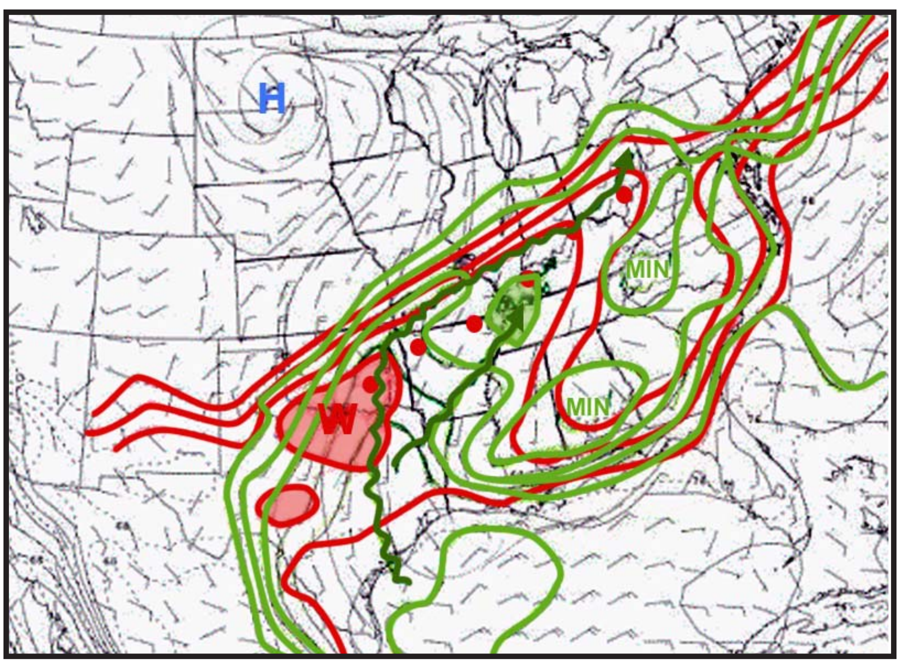

Figure 5-35. 00-Hour Boundry Layer, 1200Z/4 October 2000. Red lines: Temperature (>60ºF) Green lines: Dew Points (>50ºF)

In Figure 5-36, a PVA lobe is depicted over the Great Lakes region (indicated by the arrow) that most likely provided the upper support for convection.

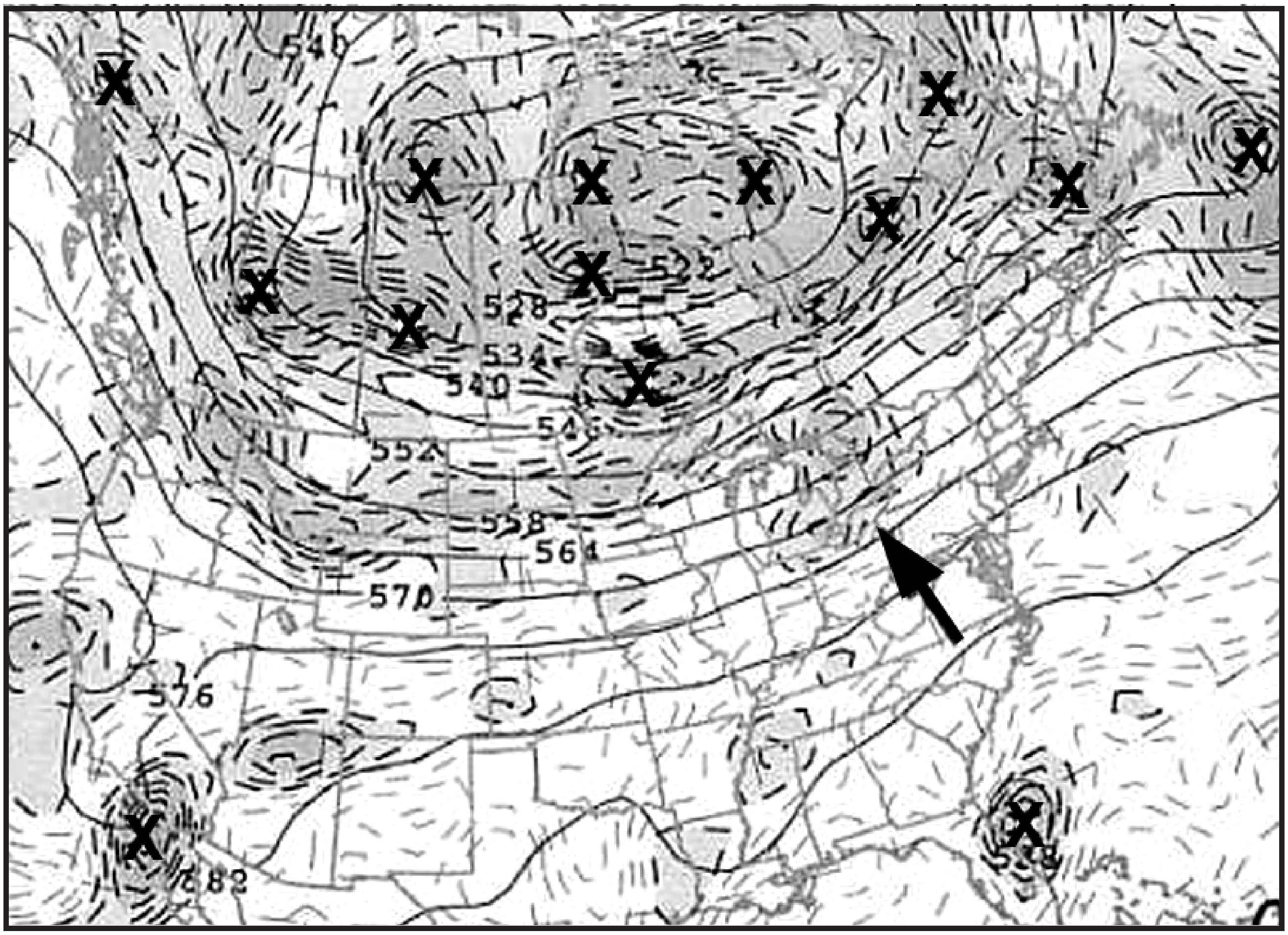

Figure 5-36. 00-Hour 500-mb Heights/Vorticity, 1200Z/4 October 2000.

NON-CONVECTIVE SURFACE WIND REGIMES (NOTORIOUS WIND BOXES)

Great Lakes and the Appalachian Mountains Boxes. These two wind regimes occur frequently during the winter season but are included here since their onsets generally begin in November. The prevailing wind direction in the Great Lakes and the Appalachian Mountains boxes is west to northwest. Figure 5-37, depicts Great Lakes areas affected by strong cold air advection (CAA) winds. When a large-scale cyclonic circulation occurs over the eastern United States, it would be difficult to discern between these two wind events.

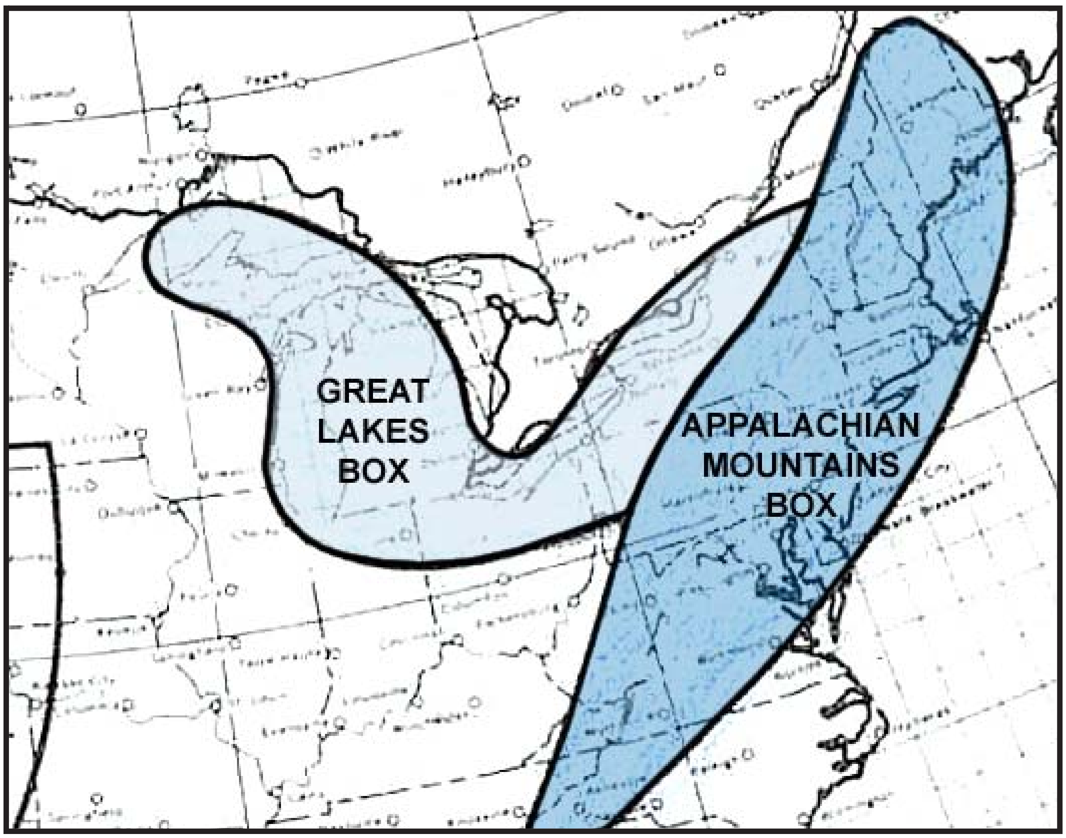

Figure 5-37. Great Lakes and Appalachian Mountains Boxes.

Appalachian Mountains Box. The Appalachian Mountains Box occurs most often when strong cold fronts move across the mountains from New England to northwestern Georgia. Forecasters should look for tight pressure gradients and strong pressure rise to fall couplets. Several scenarios for strong Appalachian Mountain wind events are documented, but the most common pattern is shown in Figures 5-38 and 5-39. Often, the first indicators of strong cold air advection winds that will affect locations east of the mountains are along the Appalachian ridge line as the cold air rushes down the lee-side.

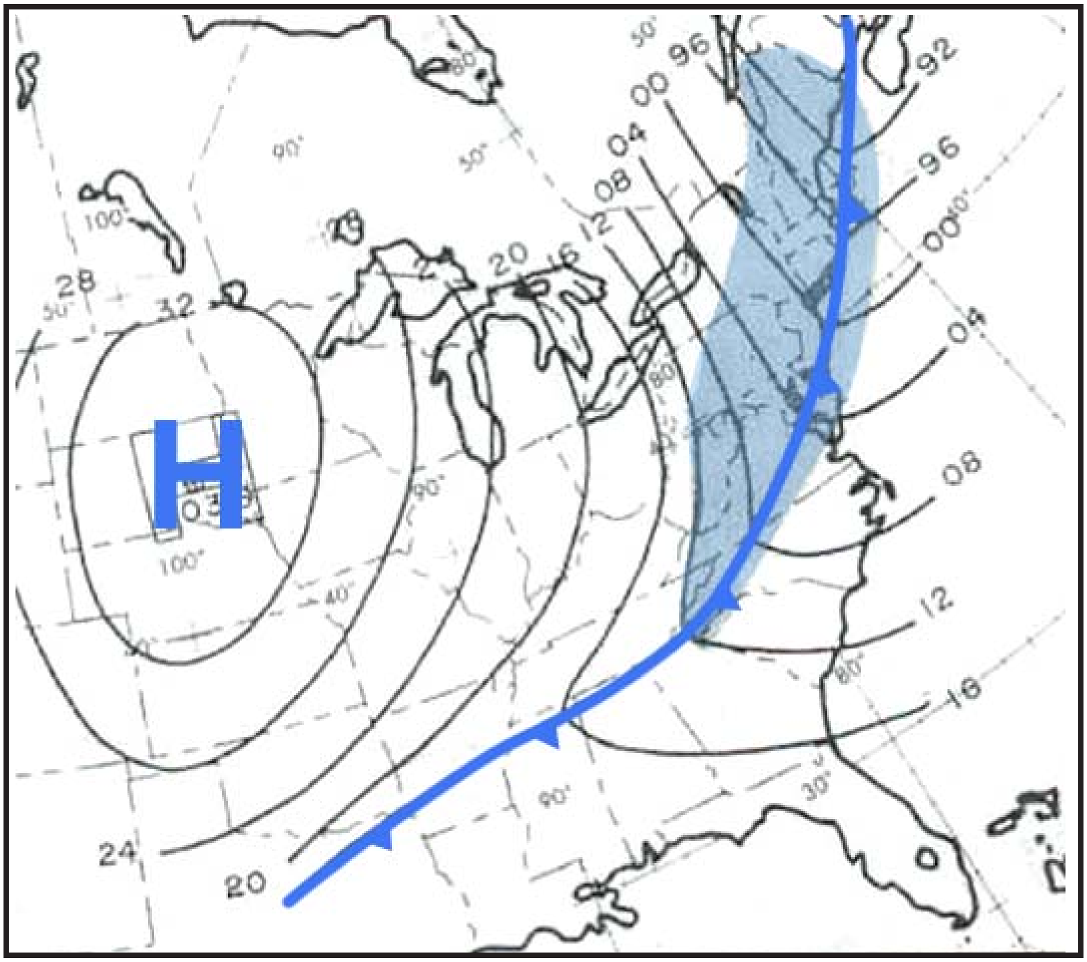

Figure 5-38. Appalachian Mountains Box Surface Example.

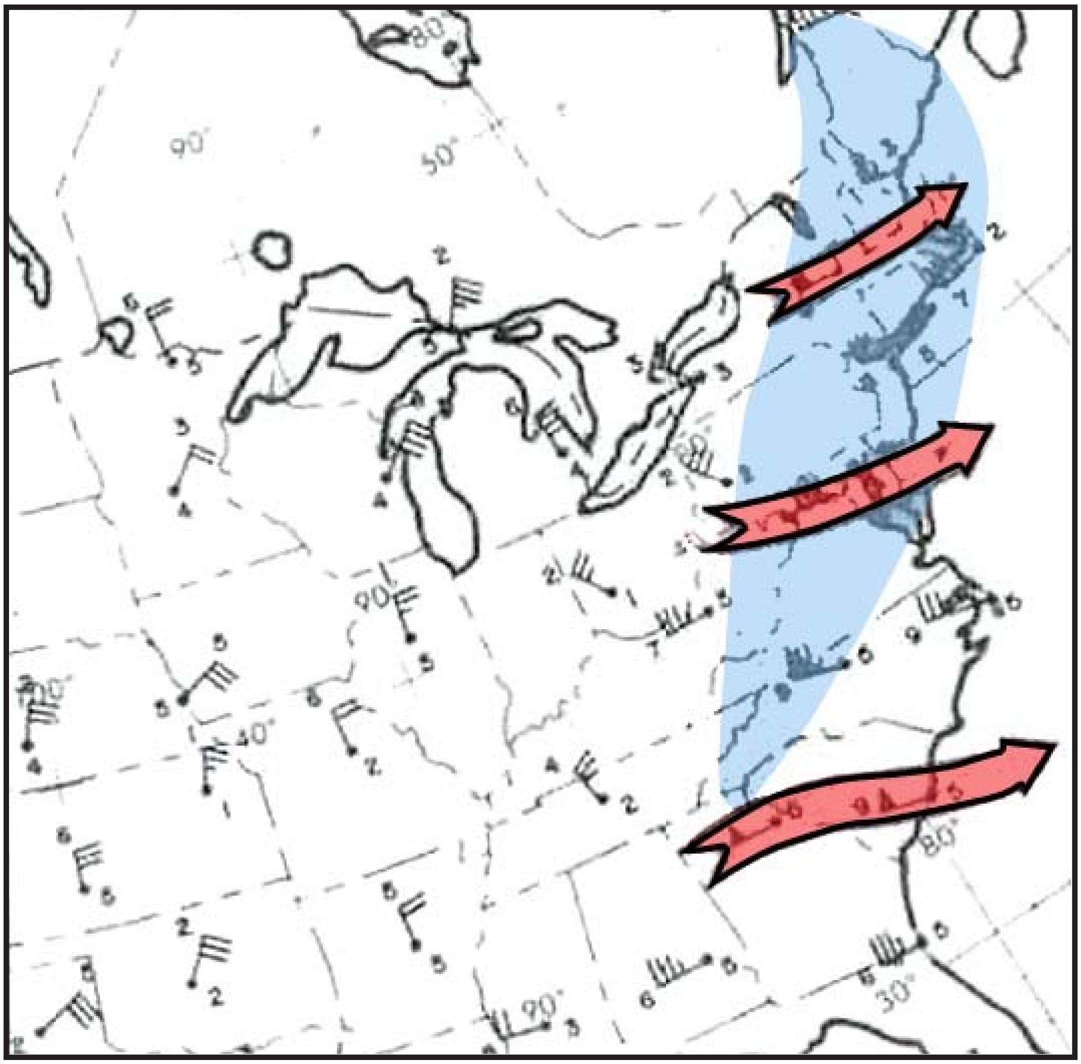

Figure 5-39. Appalachian Mountains Box Low- Level Winds Example.

FREEZING PRECIPITATION – EASTERN UNITED STATES

Synoptic-scale freezing rain events over the eastern United States are rare through mid-November (see Winter Regimes for freezing precipitation discussions). Patchy freezing drizzle, associated with stratus over areas of the Great Lakes and eastward into western New York and Pennsylvania, and also along the east slopes of the Appalachian Mountains may begin during late October when cP air masses/fronts stagnate over these areas (strong low-level inversions).

LAKE-EFFECT SNOWS IN THE GREAT LAKES.

Although a winter regime, lake-effect snow events may begin by mid-November when strong fetches of cold air for the season advect across the Great Lakes. Frequent periods of low ceilings, snow showers and gusty northwest winds affect Great Lakes locations and eastward to Pennsylvania and New York especially when strong lows move into New England and southeastern Canada (Figures 5-40). Western areas of New York and Pennsylvania affected by the "Great Lake Effect" receive heavy snowfall when slow-moving, deep

occluded lows are located over the Hudson Bay – Labrador region. This pattern continues until a low-level ridge moves in from the west and shifts winds to southerly component as shown in Figure 5-40. Locations affected by this localized heavy snowfall regime have many good rules that use temperatures differentials, low-level wind direction and strength between land and water surfaces. These rules help to predict convergent cloud lines over the lakes and their movements and where to expect heavy snow to fall. Considerable discussion and illustrations are presented in Winter Regimes.

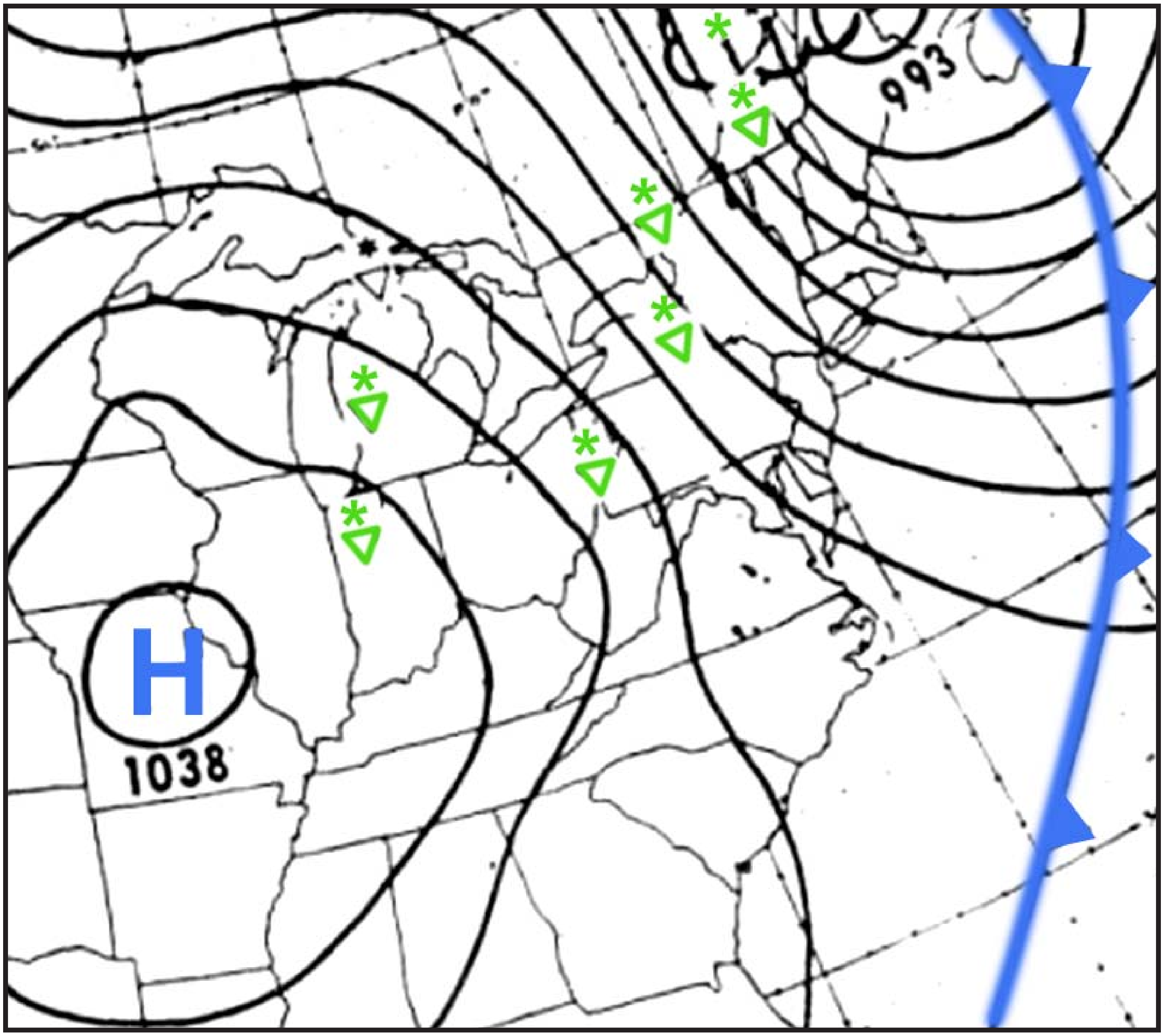

Figure 5-40. Surface Analysis, 1800Z/8 December 1979. Ridging is approaching from the west.

A strong Great Lake Effect event occurred on November 22, 2000; Buffalo, New York (KBUF) received heavy snowfall from this event (see Winter Regimes for a more detailed analysis of this event). Figures 5-41 and 5-42 show the cloud banding and lake effect snows that occurred. Figure 5-41 (GOES-E VISIBLE) indicates the large areal expanse of this storm system. Figure 5-42 (from the NOAA OSEI Archives) had a more regional focus.

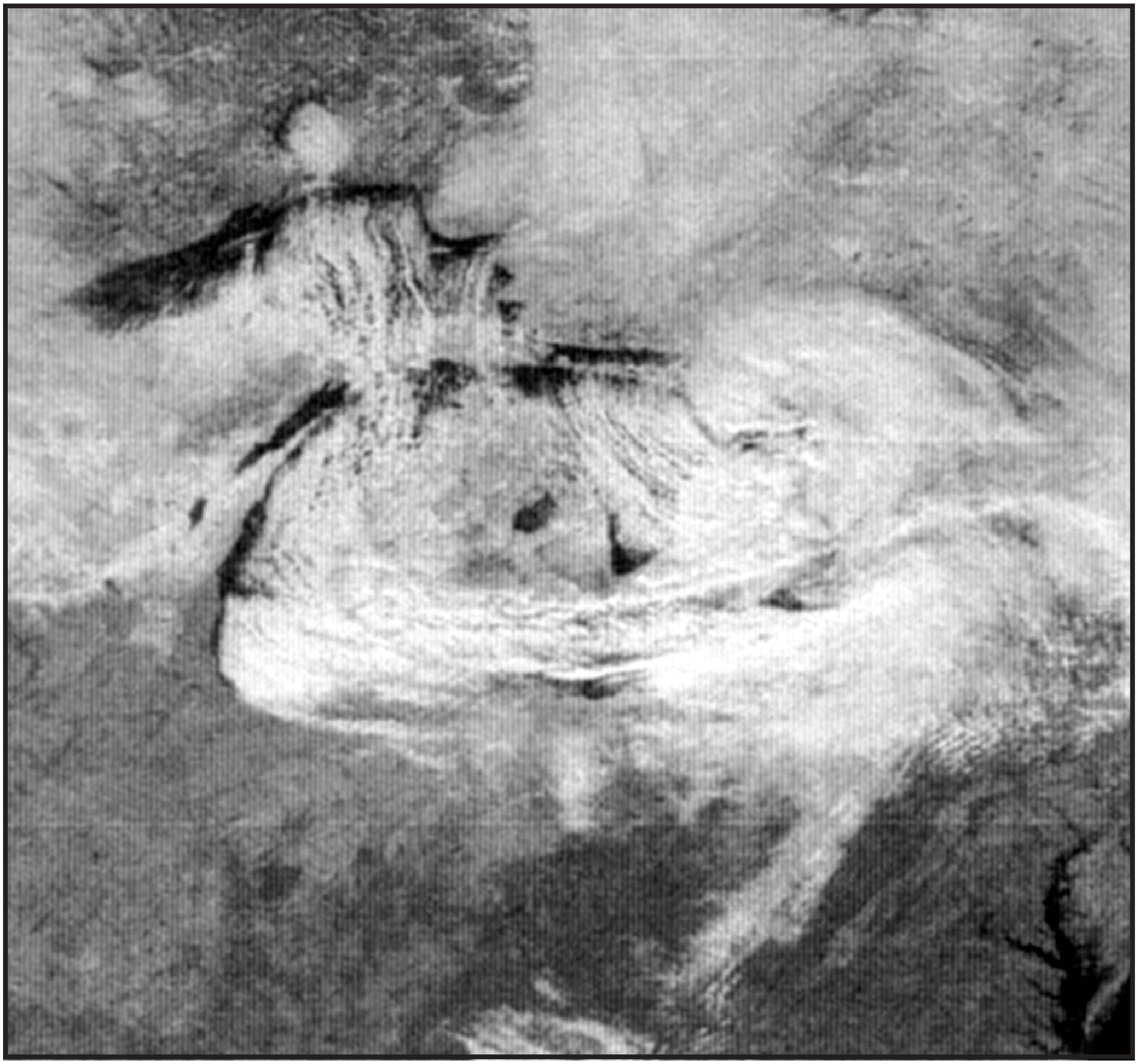

Figure 5-41. GOES-E Visible, 1702Z/22 November 2000. Extensive lake effect cloud bands that produced heavy snowfall.

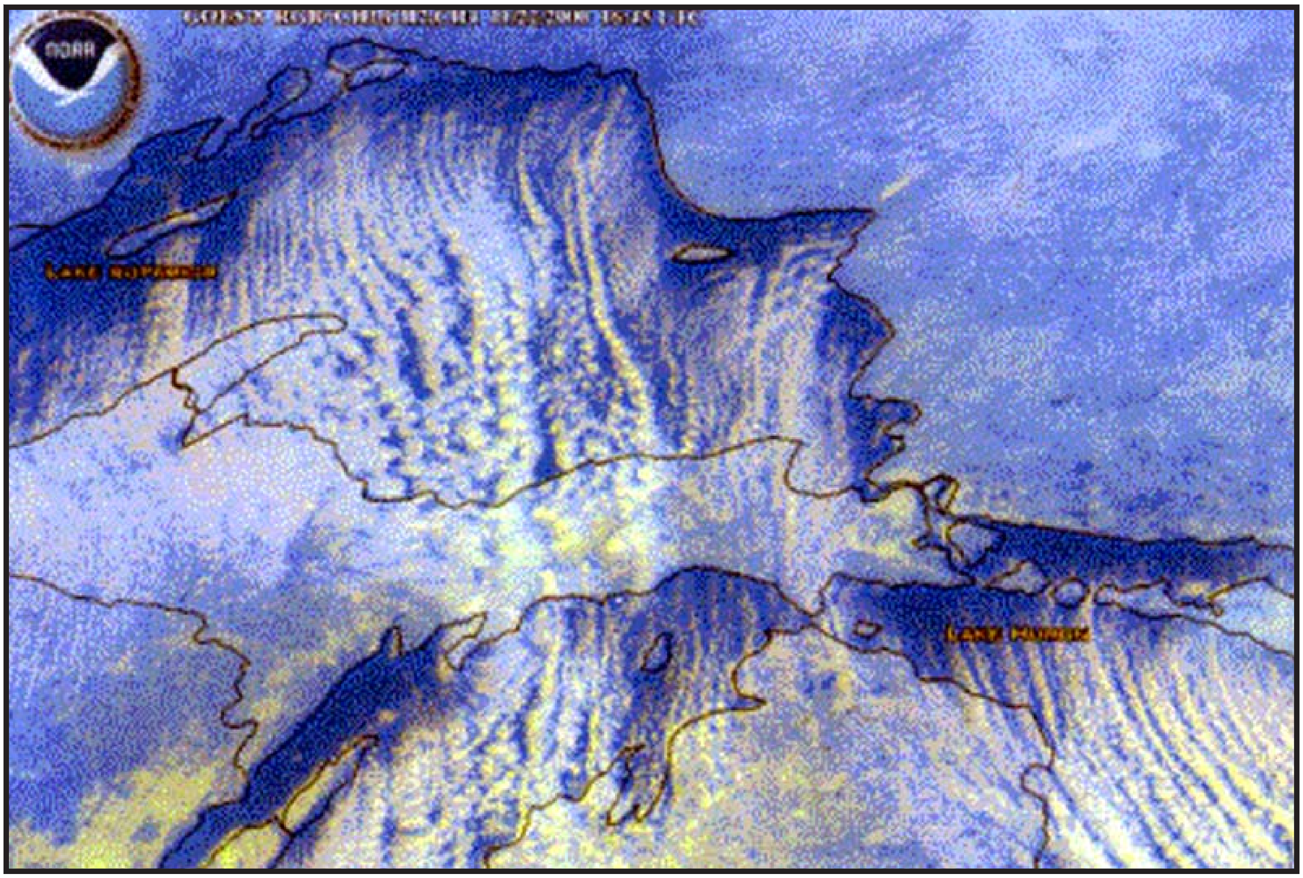

Figure 5-42. GOES-E Colored Visible, 1645Z/22November 2000. Clouds are aligned north to south associated with low-level convergent lines.

ATLANTIC AND GULF OF MEXICO TROPICAL 1ACTIVITY.

The appearance of tropical storms that affect the Gulf Coast and the Atlantic Seaboard continues through September and into mid-November. Atlantic and Gulf Coast forecasters should be aware that disturbances located close to the coast might evolve into a tropical depression or storm within a period of several days or less. In Figure 5-43, Tropical Storm Helene is shown over the southeastern United States; this system moved northward from the southern Gulf of Mexico several days earlier.

Figures 5-44 and 5-45a-b depict two more September hurricane events.

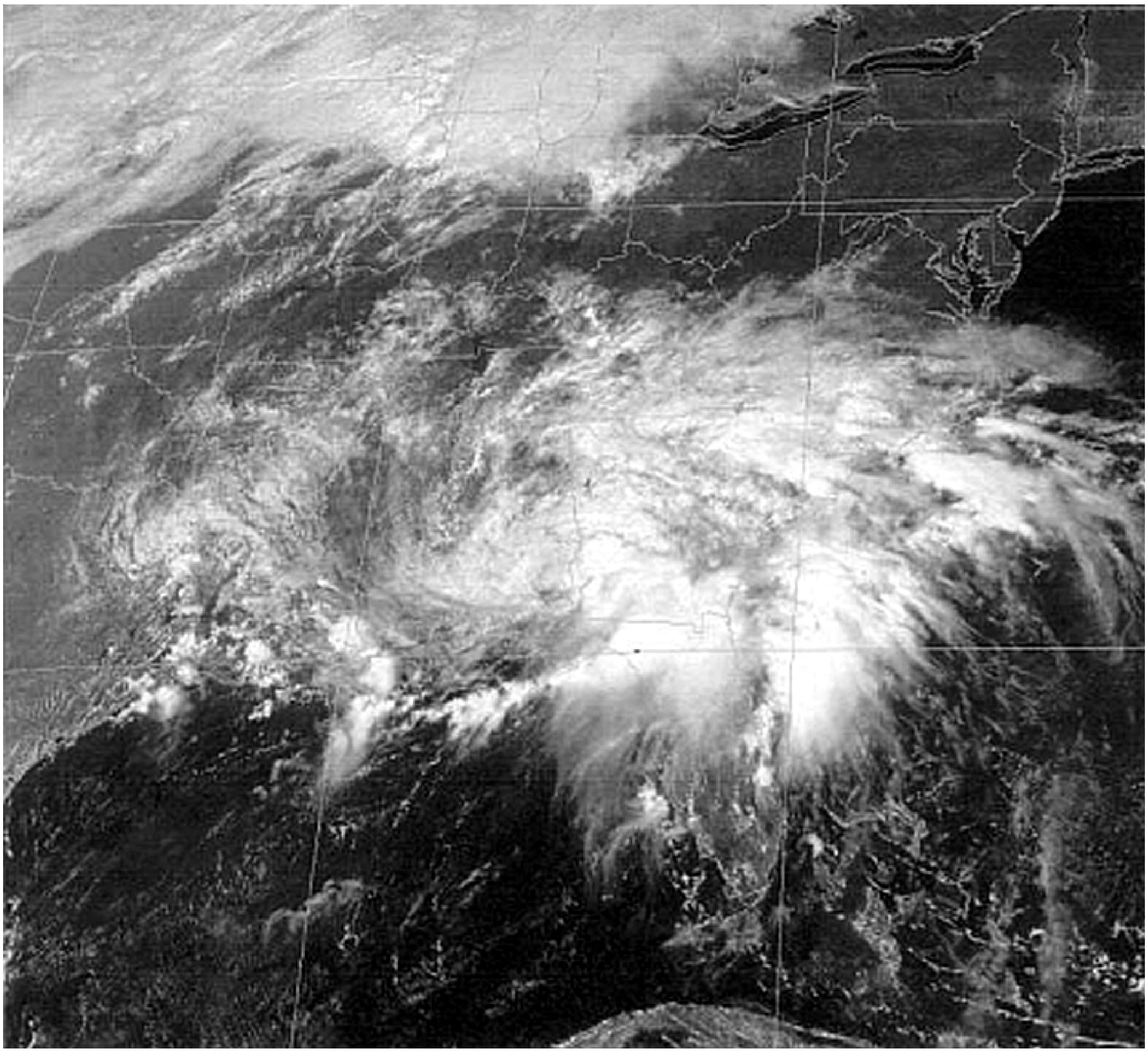

Figure 5-43. GOES East Visible, 1715Z/22 September 2000. Considerable thunderstorm activity over the southeastern United States associated with weakening tropical storm Helene.

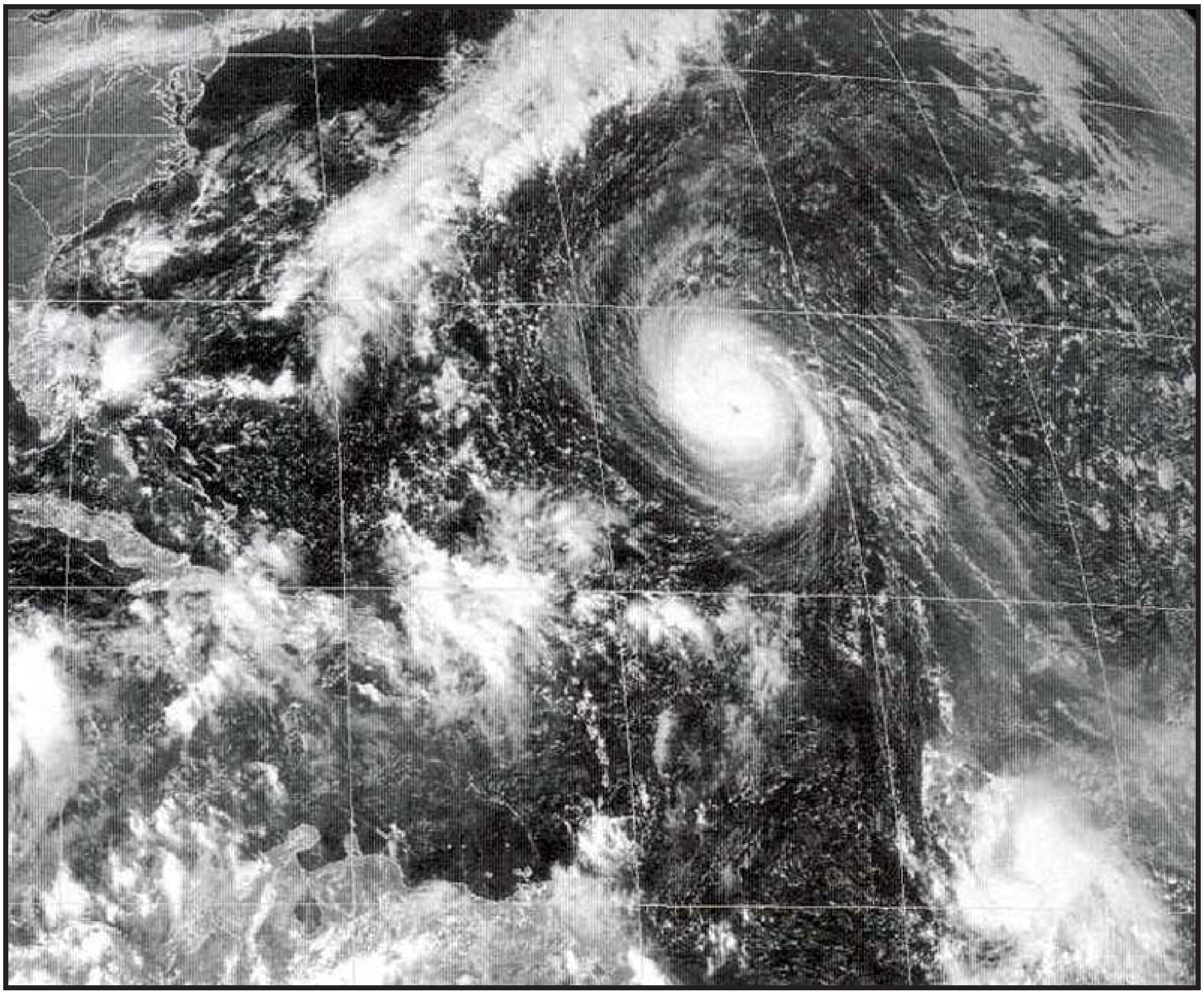

Figure 5-44. GOES East Visible, 1715Z/28 September 2000. Hurricane Isaac turned northeastward 18 hours later in the mid-Atlantic. Swells from this powerful hurricane affected the eastern seaboard.

In Figure 5-45a, powerful Hurricane Isabel with a well-defined eye is tracking northwestward towards the East Coast.

Four days later (Figure 5-45b), Hurricane Isabel spread strong surface winds and heavy rainfall across the eastern North Carolina-Virginia region.

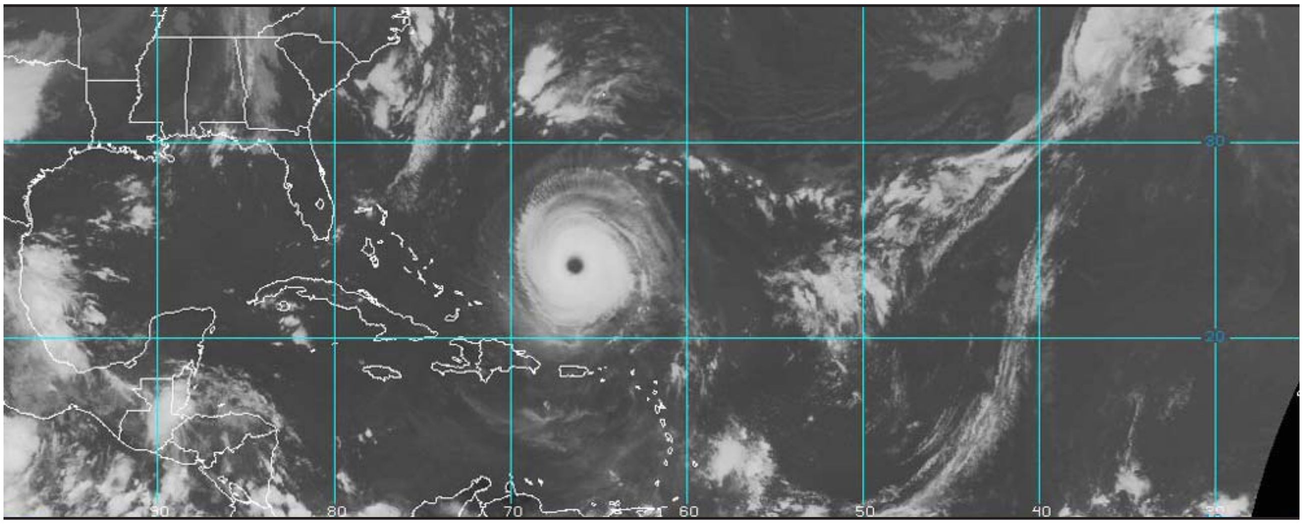

Figure 5-45a. GOES East IR, 1445Z/14 September 2003. I

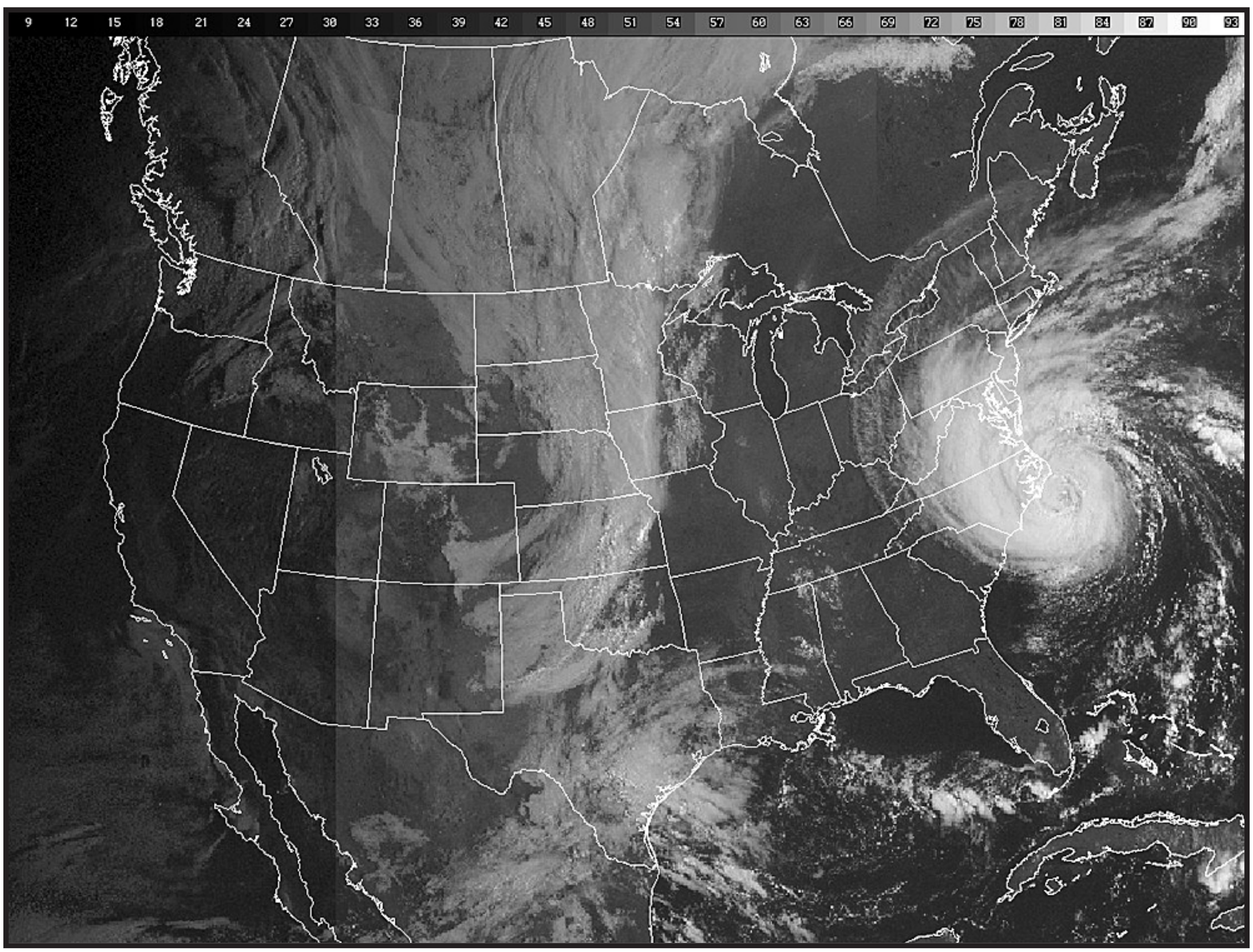

Figure 5-45b. GOES East Visible, 1430Z/18 September 2003.

Figures 5-46 and 5-47 show two October hurricane events. By late October and continuing into November, tropical storm and hurricane tracks may develop southward across the southern Gulf of Mexico and the Caribbean Sea as shown in Figure 5-47.

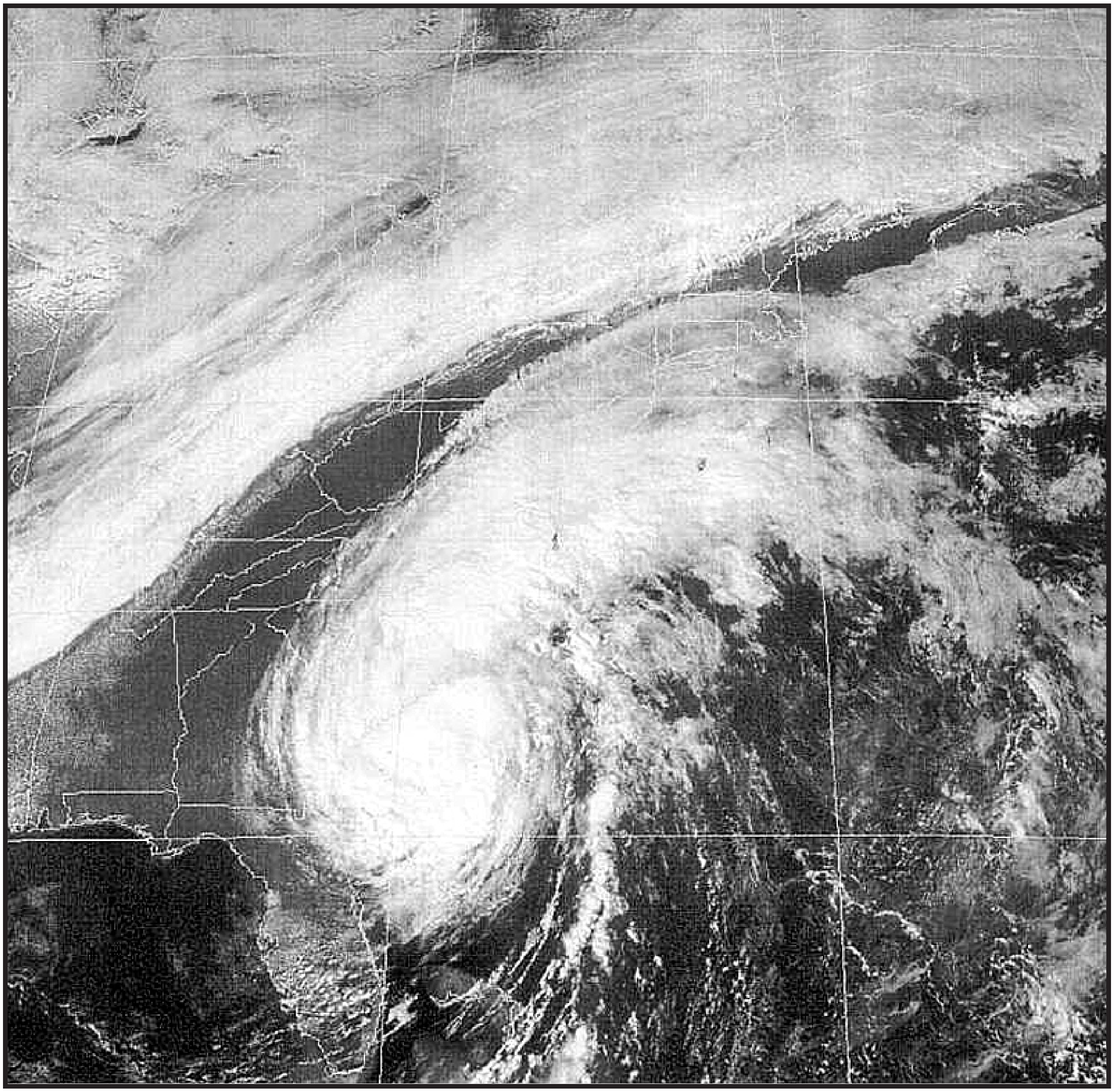

Figure 5-46. GOES East Visible, 1815Z/17 October 1999. Hurricane Irene moved across the southeastern tip of Florida and tracked northeastward along the Carolinas' coast.

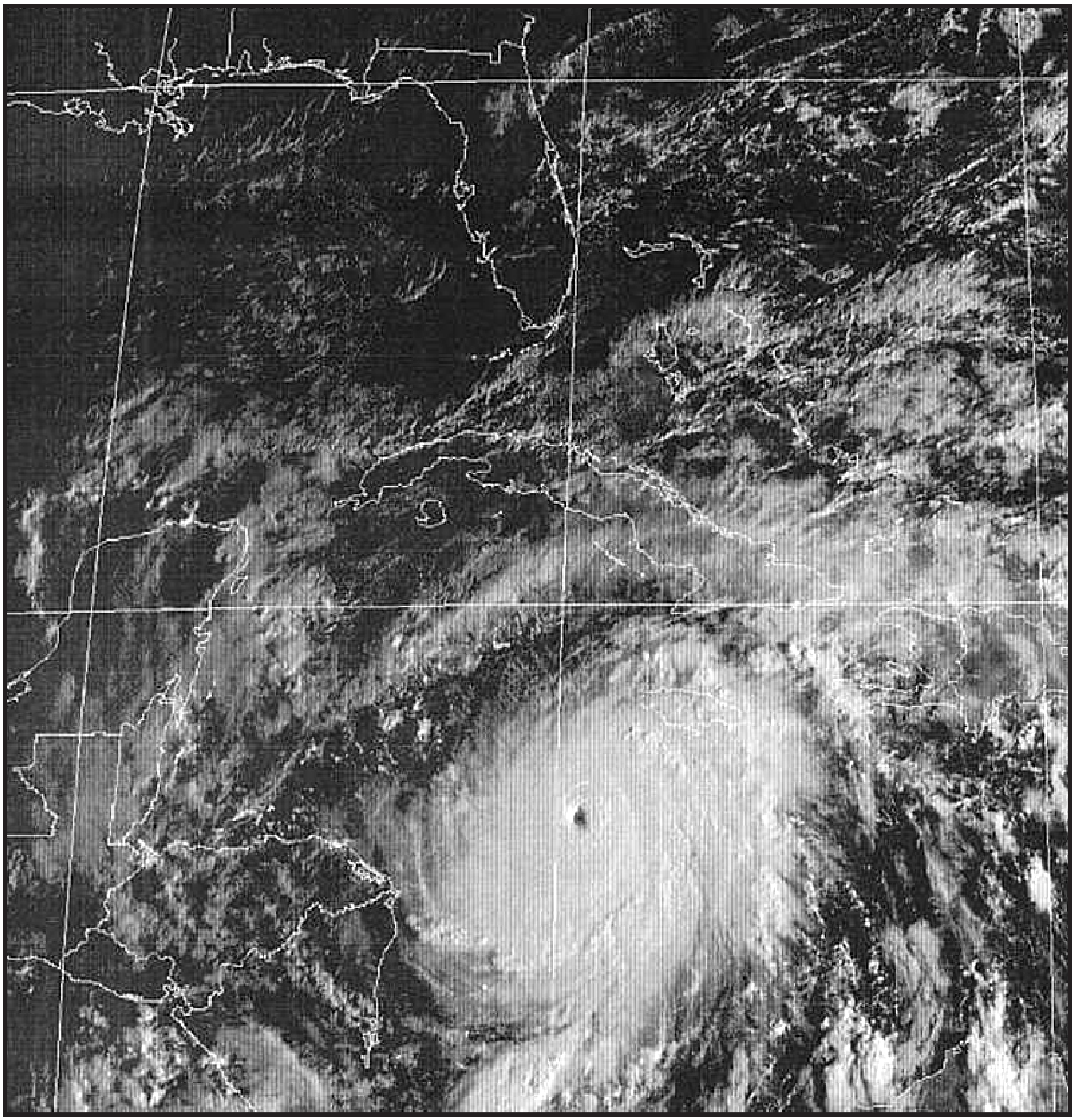

Figure 5-47. GOES East Visible, 1215Z/25 October 1998. Hurricane Mitch moving westward over the Caribbean Sea.

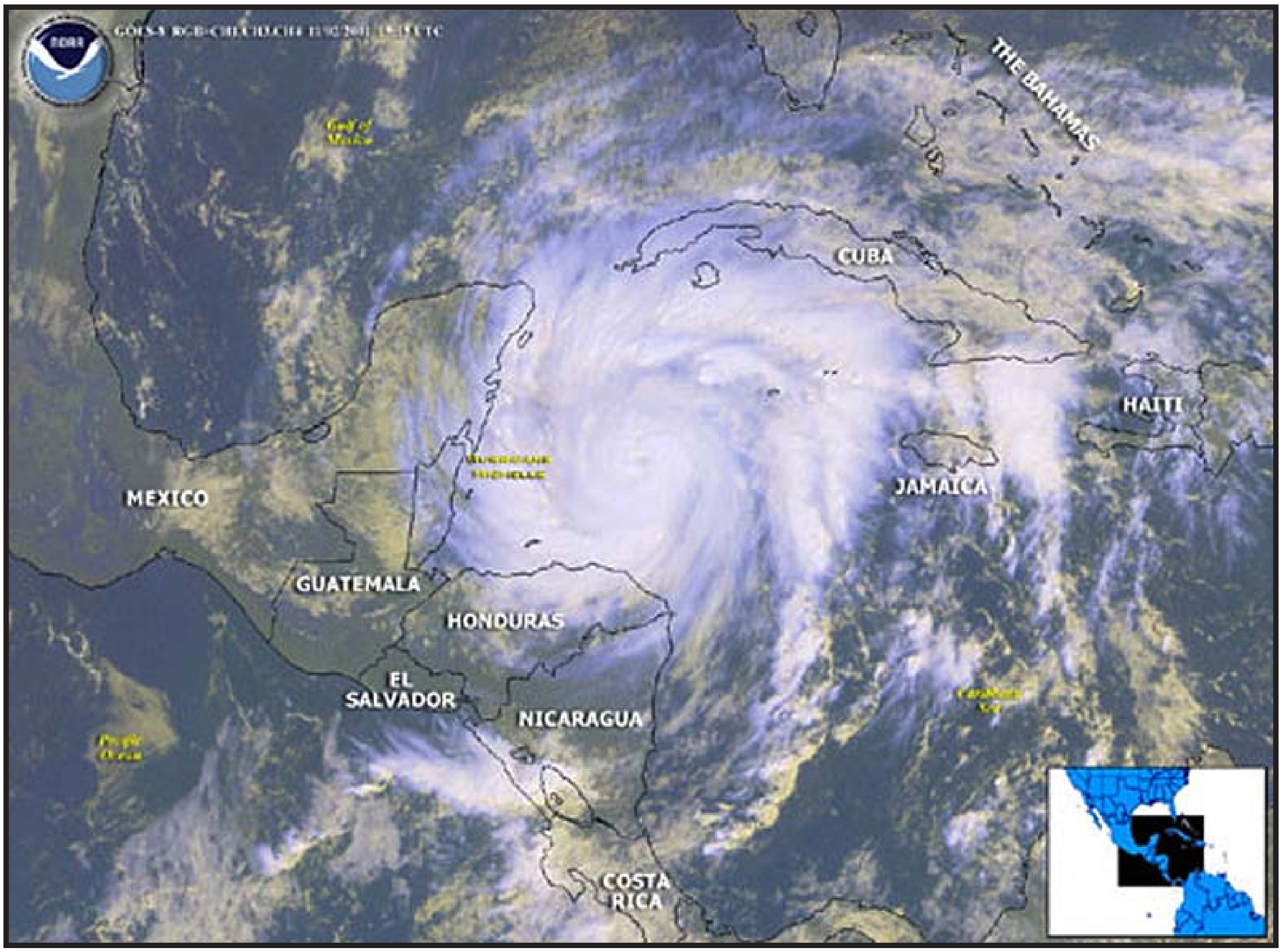

Figure 5-48. GOES East Enhanced Infrared, 1900Z/2 November 2001.

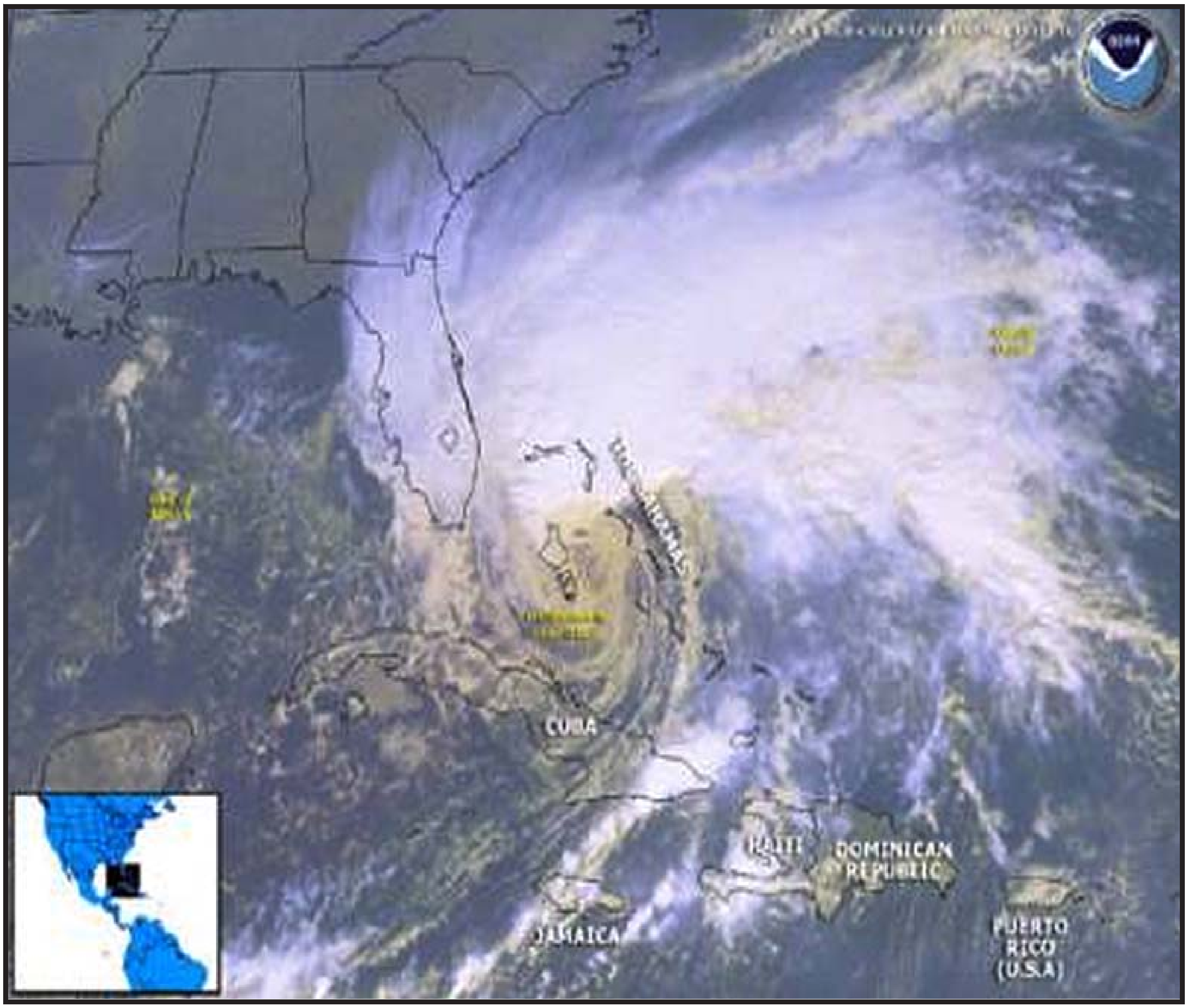

Figure 5-49. GOES East Enhanced Infrared, 1900Z/5 November 2001

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